# Essential Oils of Tropical *Asteromyrtus*, *Callistemon* and *Melaleuca* Species

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## In Search of Interesting Oils with Commercial Potential

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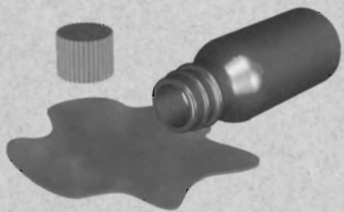

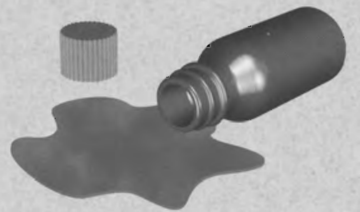

# Preface

Essential oils are aromatic, volatile extractives from plants (leaves, flowers, fruit, bark and wood) usually obtained by the technologically simple process of steam distillation. They are used as flavours, fragrances and for medicinal or health-care purposes. Verlet (1993) estimated total world production of essential oils in 1991 at 45 000 tonnes with an approximate value of US$700 million. Although many of the components of essential oils can be produced synthetically, a market preference for natural products has ensured not only the survival of the industry but provided it with a steady growth rate. Prospects for the future also look good as living standards rise and especially in Asia with a culture of utilising natural products.

The rationale for this study came from the knowledge that the oils of the entire suite of tropical melaleucas and selected close relatives in the Australasian region had not been studied in detail. Various *Melaleuca* species have provided the basis for major industries (e.g. Australian tea tree oil, Cajuput oil (Indonesia) and Niaouli oil (New Caledonia)). The Indonesian Cajuput oil industry which is based on the leaf oils of both natural and planted stands of *M. cajuputi* is described in some detail in the introduction, as an example of the successful use of a tropical melaleuca for the production of essential oils. It was hoped that this study might identify some new or interesting oils in the species screened that might have commercial potential, so as to increase the range of options available to would-be essential oil producers in tropical environments.

Predicting which of the oils highlighted in this report could be the basis of new industries, and in what localities production would be feasible, is difficult. Any new development should be market driven, so inputs are now required from industry to identify possible oils of commerce. Once suitable oils are identified, the next step of evaluating the performance of the source species in a range of environments can proceed.

# Summary


This survey identified a number of species that produced oils of possible commercial potential and these are briefly described below.

- *Asteromyrtus lysicephala*, *A. magnifica* and *A. symphyocarpa* produce "Cajuput" type oils of reasonable quality and may be commercial if production costs were low enough.

- *Melaleuca acacioides* subsp. *acacioides* essential oil has a pleasant and interesting odour of possible interest in perfumery. Oil yields of the samples tested were low (0.3-0.8% on air-dry leaves). Higher yielding forms would need to be located for any economic benefit to be obtained from its harvesting.

- *M. acacioides* subsp. *alsophila* produced a chemotype rich in terpinen-4-ol with significant proportions of neral and geranial, giving it a pleasant lemon scent. However, the oil yield was low (0.1-0.6% on fresh leaves) and much higher yielding forms would need to be located to stimulate commercial interest.

- *M. bracteata* produces a pleasant smelling oil (due mainly to the presence of methyl cinnamate in small amounts in the oil). This species is a potential source of the aromatic alkenyl ethers, methyl eugenol, methyl isoeugenol, and elemicin. However, the oil yield is, on the most part, too low for the oil to be of economic use.

- *M. cajuputi* subsp. "*cajuputi*" is the commercial source of "Cajuput" oil. The other subspecies, subsp. "*cumingiana*" and subsp. "*platyphylla*", do not appear to produce the cineole-rich oil-of-commerce, and even subsp. "*cajuputi*" is highly variable. Potential new producers of "Cajuput" oil should be extremely careful to source their seed from proven provenances.

☼ Platyphyllol has been shown to have sunscreen and biocidal properties. This compound has been isolated from the oils of one provenance of *M. cajuputi* subsp. "*platyphylla*". A rich natural source of this compound combined with good yields could have commercial potential.

☼ *M. citrolens* exists in four chemotypes, two of which (Chemotypes III and IV) produce very pleasant, lemon scented oils and in yields (up to 4% on air-dry leaves) that are reasonable. Chemotype II produces a mint scented oil, also in good yield (up to 6% on air-dry leaves). Further studies are needed to test if seed from the various chemotypes breeds true to type, as there can be more than one chemotype in a natural population.

☼ *M. dissitiflora* is known to produce an oil that meets the Standard (AS 2782-1985) for use in "Australian Tea Tree Oil". Only one of the two known chemotypes of this species produces this type of oil, so care should be exercised in obtaining seed of the correct chemotype for trials.

☼ *M. leucadendra* has been shown to exist in two chemotypes which are geographically based. The eastern chemotype that has an oil containing methyleugenol or methyl isoeugenol is a potential commercial source of these compounds.

☼ *M. quinquenervia* occurs in two chemotypes. The cineole-rich type is the source of Niaouli oil which is produced commercially from natural stands of this species in New Caledonia. The nerolidol chemotype may also be of use, if its oil could be produced economically.

☼ *M. viridiflora* has one chemotype with an oil rich in methyl cinnamate, with lesser amounts of E-β-ocimene, and a reasonable oil yield (4% on air-dry leaves). It could possibly be developed into a useful tropical source of natural methyl cinnamate. It has been reported that this chemotype can be readily distinguished in the field from other *M. viridiflora* types by the colour of its leaves. If this proves reliable, it should be relatively easy then to source seed from parent trees of the correct chemotype for further work.

☼ *M.* sp. "Bukbuluk" produces a pleasing, lemon scented oil which contains significant amounts of terpinen-4-ol (11%). The oil yield (up to 3.1% on fresh leaves) is reasonable and this species may warrant further examination as a pleasant smelling natural antiseptic and medicinal oil.

None of the *Callistemon* species studied so far appears to have any commercial potential.

To be commercial, a species must produce an oil of value and it must be produced in good yield. The actual yield needed would depend on just how valuable the oil was to the market-place. A critical analysis of which of the species examined herein would warrant domesticating as a commercial oil crop is beyond the scope of this report and would require industry and marketing experience, including a more thorough examination of individual species by essential oil growers.

# Introduction

## General information on genera

The closely related genera *Asteromyrtus*, *Callistemon* and *Melaleuca*, form part of the *Leptospermum* alliance within the family Myrtaceae. *Asteromyrtus* is a recently reinstated genus (Craven 1988) of seven species, formerly accommodated in *Sinoga* (*S. lysicephala*) or *Melaleuca*. All species are tropical in origin and are mainly shrubs and small trees that occur in northern Australia and adjacent areas in southern Papua New Guinea and Indonesia. Six species are covered in the report, while the remaining member of the group, *A. tranganensis* Craven, which is known only from one herbarium collection from the Aru Islands off the coast of Irian Jaya, awaits rediscovery and study of its oils.

*Callistemon* consists of woody shrubs or small trees commonly referred to as bottlebrushes after their flowers which are arranged in dense, cylindrical spikes. The genus is closely allied to *Melaleuca* and is also under review taxonomically where major changes in nomenclature are foreshadowed. The 30 species which occur naturally in Australia are all endemic (Wrigley and Fagg 1993). The greatest variety is found in temperate climates but several species extend to tropical regions. The oils of four such species are described in this report.

*Melaleuca*, referred to commonly as paperbarks, is the largest genus in the alliance, and could comprise of as many as 250 species, following a major taxonomic revision that is currently in progress. It is predominantly Australian, where it occurs throughout the continent in many forms ranging from small, sometimes prostrate to semi-prostrate shrubs common in sandy heaths of the southwest, to large forest trees over 40 m tall in the tropical swamps of the north. Only about nine species have been recorded outside of Australia (Barlow 1988). The 26 species highlighted in this report are all tropical in origin. They are mainly medium to large trees with a marked preference for damp or wet depositional landforms which may partially dry out seasonally; such sites are often coastal and include areas where there is water of varying salinity.

## Utilisation

Many of the species described herein are of value in environmental and social forestry in the tropics. Their wood is mostly hard, moderately dense, resistant to rot, often high in silica content and used mainly as posts and poles, piling and fuelwood. Most species are good sources of honey and are useful for amenity planting, shelterbelts and erosion control on difficult sites where few other trees thrive (e.g. on swampy ground; sites subject to salt spray). Several species have ornamental cultivars.

Production of foliar essential oils, as is already done commercially utilising several of the species described in this report, is arguably the most important commercial use of this group of species. A brief description follows of the Cajuput oil industry in Indonesia, based on *M. cajuputi*, as an example of a long-established and successful industry. In addition, Niaouli oil is produced commercially from *M. quinquenervia* in New Caledonia (Guenther 1950) and some minor production of Cajuput oil from *A. symphyocarpa* takes place in Irian Jaya. However, there are several other species in this group that have the potential to become sources of oils of commerce but await recognition and development for this purpose. A main objective of this report was to identify species with oils of commercial potential for planting in tropical environments.

## Case study—Cajuput oil

Cajuput (also spelt "cajaput" or "cajeput") oil (or Minyak Kayu Putih in Indonesia), obtained by the steam distillation of leaves of *M. cajuputi* (syn. *M. leucadendron*), has been a popular household medication in countries such as India, Indonesia, Malaysia and Vietnam for centuries. The Australian Aborigines used preparations from the leaves of this species in the treatment of aches and pains and inhaled the aromatic vapours from crushed leaves to reduce nasal and bronchial congestion (Aboriginal Communities of the N.T. 1993). Because of its reputation as a panacea in the treatment of all kinds of diseases, the Dutch made it one of the first products they imported to Europe from Southeast Asia, an activity may partially dry out seasonally; such sites are often coastal and include areas where there is water of varying salinity.

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### Plant source

*M. cajuputi* is usually a single-stemmed, small tree up to 25 m tall, although it may reach 40 m and 1.2 m in diameter in some situations (Fig. 1.1). It carries dense, erect dull green foliage with grey to white papery bark. The exact limits of the natural range of *M. cajuputi* are not known as the species has been cultivated in Asia for more than 100 years. The approximate boundaries are given in Figure 1.2. The western portion of the distribution, taking in several countries in Southeast Asia, is geographically disjunct from the Australasian distribution and represents the only natural occurrence of *Melaleuca* beyond the Australian geophysical boundary (Barlow 1988). The approximate latitudinal range is 12°N–18°S and the range in altitude 5–400 m. There are plans to recognise three subspecies within *M. cajuputi* more-or-less consistent with the three areas of distribution (A, B, C) indicated in Figure 1.2.

This is a species primarily of the hot humid climatic zone. Mean annual rainfall varies from 1300–1750 mm with a strong monsoonal pattern. The species grows in a wide range of situations but most stands are found on low swampy coastal plains often on heavy-textured black soils that are subject to flooding.

**Figure 1.1** Natural stands of *M. cajuputi* in Australia and Indonesia: (left) a tree at Flying Fox Creek near Kapalga, Northern Territory; (right) a small tree at Ratgelombeng, Buru Island.

An exception are populations in Indonesia on the Maluku Islands of Buru, Ceram and adjacent islands. Here extensive populations extend to gravelly ridges away from the coast.

## Properties and uses

The chemical composition of the oils of *M. cajuputi* is highly variable both within and between the three proposed subspecies. This report (see Species Digest for *M. cajuputi*) documents variation in oil chemistry found in several oil samples obtained from throughout the species range.

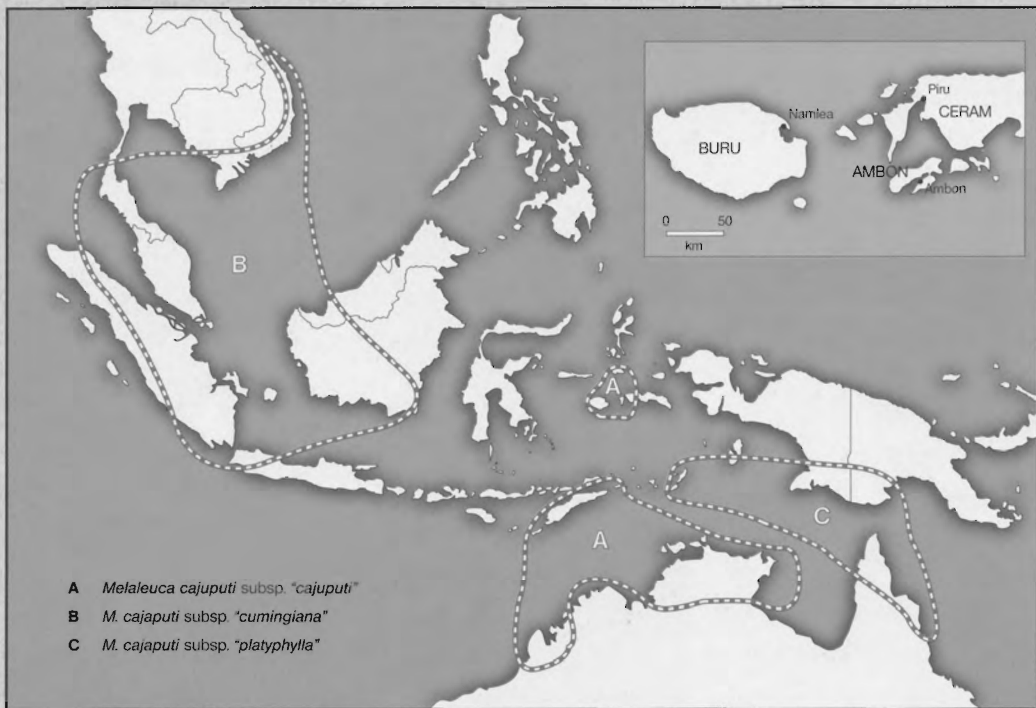



**Figure 1.2** The approximate boundaries of the natural distribution of *M. cajuputi.* The three parts of the distribution (A, B & C) shown coincide with the occurrence of three subspecies soon to be named. The Maluku Islands of Ambon, Buru and Ceram, the home of the Cajuput oil industry, are shown in greater detail in the insert to the figure.

Most commercial production of Cajuput oil takes place in Indonesia based on natural stands or plantations established from seed from the Maluku archipelago of Indonesia. This oil which hereafter will be referred to as "type" oil contains significant amounts of 1,8-cineole (40–60%), and modest quantities (2–7%) of a range of terpenes including limonene, caryophyllene, α-terpineol, viridiflorene, α- and β- pinene, γ-terpinene, α- and β-selinene, and lesser amounts of the sesquiterpene alcohols globulol, viridiflorol and spathulenol. The aromatic ether, cajeputol, reported to be in high proportions in oils of Malaysian origin (Lowry 1973) and also found in oils from Kalimantan, Indonesia (this report), was not detected in oils from this region. Oil concentration of "type" leaves usually falls in the range 0.4–1.2% (W/W%, FW).

Lassak and McCarthy (1983) described the medicinal uses of Cajuput oil: "The oil is used internally for the treatment of coughs and colds, against stomach cramps, colic and asthma; the dose is one to five drops. It is used externally for the relief of neuralgia and rheumatism, often in the form of ointments and liniments. External application of a few drops on cotton wool for the relief of toothache and earache". The oil is also reputed to have insect-repellent properties; it is a sedative and relaxant and is useful in treating worms, particularly roundworm. It is also used as a flavouring in cooking and as an ingredient in cosmetics and perfume (Sellar 1992).

### *Supply, quality and prices*

The provision of detailed information on markets for Cajuput oil, supply sources, quality and prices is beyond the scope of this report. However, from data in-hand some generalisations are possible. In Indonesia, there are two sources of "type" oils. Estimates of production from the natural stands on the Maluku archipelago suggest that some 80 tonnes of oil are produced annually (Gunn et al. 1996). Production from plantations on Java, established using seed from trees from the Maluku Islands, amounted to approximately 280 tonnes in 1993 (Ministry of Forestry 1995). Oil was extracted from natural stands in Vietnam in the very recent past, when production for mainly local consumption was estimated to be 100 tonnes per annum (Hodacova and Ubik 1990). However, it has not be possible to confirm if this level of production in Vietnam continues. Total annual production of Cajuput oil, therefore, amounts to some 350–450 tonnes, and, according to Indonesian sources, demand for oil mostly exceeds supply. With the current distillery-gate price for oil in Indonesia at US$7.2 per kg, this approximates to a US$3M industry before value-adding.

There is no accepted International Quality Standard for Cajuput oil. As a result, commercial Cajuput oils may differ very significantly from one another in a number of characteristics (e.g. chemical composition, colour, smell). This is due to a number of factors:

- different chemotypes within and between proposed subspecies;
- different plant sources (e.g. *Asteromyrtus symphyocarpa* may be used as a source of Cajuput oil in Irian Jaya);
- blending with other oils such as *Eucalyptus*; and
- adulteration with synthetic compounds not found in nature.

Ultimately, this lack of uniformity, against a background of increasing quality assurance within the essential oil industry, must damage the Cajuput oil industry and will perhaps force the adoption of quality standards.

### Production of oil from natural stands in Indonesia

Traditional landowners on the Maluku Islands of Buru, Ceram and Ambon are the principal producers in Indonesia of oil from natural stands of *M. cajuput* (Fig. 1.3). Most of the oil is produced on Buru Island which is mountainous and of volcanic origin and has contrasting vegetation cover. Most ridges and slopes of the northern coastline and those along the major Wai Apu River flowing to the east coast have sparse vegetation comprising of open woodlands and low shrublands of *M. cajuputi* (altitude 30–400 m). There are some 100 000 ha of this vegetation type available for oil production on Buru. The reddish soils of the slopes are frequently gravelly, shallow and slightly to moderately acidic, although some populations of *M. cajuputi* on Buru are found on alluvial soils of impeded drainage, which is the more typical environment for this species. All Buru *M. cajuputi* populations visited during a joint Indonesian/Australian seed collection expedition in 1995 showed evidence of harvesting for essential oils and the ravages of frequent fires (Gunn et al. 1996).

**Figure 1.3** Natural stands of *M. cajuputi* on Ceram Island that have been harvested for centuries for Cajuput oil production.

*M. cajuputi* is found in western Ceram where it is harvested for oils. The species occurs as an almost pure and continuous stand of some 150 000 ha along the Hoamoal Peninsula. Scattered populations occur elsewhere and also on the three islands between Ceram and Buru, namely Boana, Kelang and Manipa. The distribution of *M. cajuputi* on Ceram is associated with lowland plains and low undulating mountain ridges between 30–150 m above sea level, and the soil type resembles that observed on Buru (Gunn et al. 1996). There appear to be only a few scattered stands of *M. cajuputi* on Ambon Island which is wetter and generally more fertile than the other islands. One is on an undulating ridge (altitude about 60 m) near Mt Salahutu on Hitu Peninsula and is relatively small (ca. 5 ha). It is comprised of straggly low trees to 4 m, many of which had been coppiced during leaf harvesting for oils when visited in 1995 (Gunn et al. 1996).

## Leaf harvesting and distillation methods

The harvesting of leaves is a family operation with groups of 2 to 6 people involved in the sequential harvesting of family holdings of some 200 ha of *M. cajuputi*. Coppice growth of 1–2 m (6–12 months old) is cut with machetes and leaves stripped into 20 kg baskets (Fig. 1.4). A skilled cutter can harvest seven baskets per day. The dry-season months of May to August are the preferred time of harvest because of reputedly better yield at this time but harvesting may take place throughout the year. After transport to the family still, the leaves may be spread out in the sun for a few days to reduce leaf moisture content.

The still is usually a permanent fixture made from mostly local materials (Fig. 1.5). The distillation vessel (pot) is commonly made from planks butted together with cajuput bark used as a sealant. The lid is made of wood whilst the condenser which comprises a dome and single pipe, sometimes with baffle, is made of mild brass and is purchased by the still owner. Still capacity is usually about 160 kg of dried leaves and cooking time extends for 8 hours. Yield per cook from these stills approximates 3 kg of oil. Unconfirmed estimates (B.V. Gunn, pers. comm.) suggest there are about 100 family stills operating on Buru, 10–12 on Ceram and one or two operating on each of the islands of Boano, Manipa, Keland and Ambon.

**Figure 1.4** Women harvest leaves of *M. cajuputi* on Ceram Island for the production of Cajuput oil.

### Oil quality and price

Cajuput oil on the islands is purchased and sold in three grades which, according to locals, are determined by site of harvest. Grade 1, the best quality oil, comes from hillside operations and fetches $A11–12 per kg at the farm-gate. Grade 2, the medium quality class, comes from low elevation sites and is priced at about $A9 per kg. Gunn et al. (1996) were unable to confirm the origins of Grade 3 oil. Chemical analysis of oils from stills at various sites showed that the 1,8-cineole percentage of Grade 1 oils was indeed greater than that of Grade 2 oils (Table 1.1).

**Figure 1.5** M. *cajuputi* oil production on Buru Island is a family concern: (top) this producer air dries *M. cajuputi* leaves in the sun before distillation; (bottom) a basic wood-fired still and condenser made of wood and mild brass. Wood for the fire is stacked for drying in front of the fire. The producer is holding bottles of Cajuput oil ready for sale.

### *Production of oil from plantations on Java, Indonesia*

Early attempts to produce Cajuput oil on Java and Sumatra, presumably using plants native to that part of the species range, failed because of poor oil quality (Guenther 1950). It was not until 1926, when plantations were established at Ponorogo in East Java using seed from Buru Island, that the industry became established on Java (S. Darmono, pers. comm.). Subsequent plantings in East, Central and West Java used seed from Ponorogo. The present extent of *M. cajuputi* plantations on the island is estimated to be 12 000 ha (S. Darmono, pers. comm.), with 9000 ha under the control of Perum Perhutani (Forestry Department) (Ministry of Forestry 1995). Perum

Perhutani run the 12 distilleries on Java. There are 4 major and 8 small factories producing about 280 kg of Cajuput oil per year.

### *Leaf harvesting and distillation methods*

Plantations are established on usually degraded lands using unimproved seedlings at an initial stocking of 5000 stems per ha. These trees are allowed to grow-on for four years when they are cut off at 1.1 m above ground level in the first harvest of essential

**Table 1.1.** Composition of the three grades of Cajuput oil found in the market and in the villages on Buru Island (2 grades given here) in comparison with a Grade 2 oil from the plantations in Central Java. Quality is partly based on the abundance of 1,8-cineole in the oil which appears to be associated with the locality of harvest in the Maluku Islands.

| Principal compounds in the oil | Grade 1 Buru merchant | Grade 2 Buru merchant | Grade 3 Buru merchant | Grade 1 NW Buru villager | Grade 2 NE Buru villager | Grade 2 Java plantation |
|---|---|---|---|---|---|---|
| α-pinene | 2.1 | 2.5 | 3.1 | 2.1 | 19.5 | 3.8 |
| α-thujene | 0.3 | 0.9 | 1.2 | 0.2 | - | 0.8 |
| β-pinene | 1.1 | 0.9 | 1.1 | 1.4 | 8.6 | 2.5 |
| limonene | 5.6 | 4.9 | 4.8 | 5.2 | 17.4 | 6.9 |
| 1,8-cineole | 62.8 | 41.6 | 34.0 | 66.5 | 21.5 | 50.7 |
| γ-terpinene | 1.2 | 7.4 | 5.0 | 0.9 | 8.7 | 3.1 |
| *p*-cymene | 1.3 | 3.5 | 5.7 | 0.5 | 3.0 | 1.4 |
| terpinolene | 0.6 | 1.0 | 0.5 | 0.3 | 4.1 | 1.5 |
| β-caryophyllene | 3.7 | 6.9 | 7.4 | 3.3 | 2.8 | 4.9 |
| aromadendrene | 0.9 | 1.4 | 1.7 | 0.7 | 1.2 | 0.9 |
| humulene | 1.8 | 3.9 | 0.3 | 1.9 | 0.1 | 2.3 |
| viridiflorene | 4.5 | 3.1 | 2.5 | 3.8 | 1.7 | 3.7 |
| α-terpineol | 4.5 | 3.0 | 2.4 | 3.8 | 1.9 | 3.8 |

oils (Fig. 1.6). Thereafter the plants are visited annually when coppice shoots greater that 1 cm in diameter are selectively harvested, and leaves and twigs stripped into hessian bags for transport to the distillery. One hectare of plantation produces about 7.5 tonnes of Cajuput leaves annually which in turn produces about 60–65 kg of oil. The industry is a great employer of labour. In one operation alone in Central Java based on 3200 ha of plantation, 300 local people are engaged in harvesting leaves and a further 70 people are employed at the distillery (Ministry of Forests 1995).

**Figure 1.6** M. *cajuputi* plantations in Central Java that have been cut at 1.1 m above ground and coppiced for ease of leaf collection for Cajuput oil production.

The cajuput distillation plant of the Gundih forest district, located at Krai in Central Java, is an example of one of the four major plants operated by Perum Perhutani. The distillery operates eight, 0.9 tonne capacity pots fed by a steam boiler fuelled by the spent leaves of earlier distillations (Fig. 1.7). A four-hour distillation time is standard. Output for 1993 was 78 tonnes of oil from some 9200 tonnes of leaves and twigs, or a recovery rate of 0.85% (Ministry of Forestry 1995).

### Oil quality and price

Eighty percent of production from the Krai distillery was classified as Grade 1 oil of ca. 65% cineole content while the remainder of production was classified as Grade 2 of ca. 55% cineole content. The price paid per kilogram at the factory-gate for Grade 1 oil was $A9.4 in 1995 significantly less than the $A11–12 paid for first quality oil from the Maluku Islands. Grade 2 oil received $A8.8 per kilogram. The composition of a representative sample of Grade 2 oil from the Krai distillery is given in Table 1.1.

## New developments

Many of the plantations on Java are considered to give low yields of oil and are past their prime productivity (M. Ansorudin, pers. comm.). Perum Perhutani is making plans to gradually replace the existing plantation resource commencing about 1998. With the interest in establishing new plantations of *M. cajuputi* for oil production has come the interest in increasing the amount and value of oil produced per hectare through selecting, breeding and using genetically improved trees. Currently, there are no programs in place in Indonesia to provide improved planting stock.

**Figure 1.7** A modern Cajuput oil distillation facility at Krai in Central Java: (top left) four of the eight 0.9 tonne capacity pots at the facility; (bottom left) the steam boiler which is fuelled entirely by leaves and twigs dried after distillation; (right) stainless steel separators for collecting the oil.

The joint Australian (CSIRO)/ Indonesian (Agency for Forest Research) *M. cajuputi* seed collecting and oil screening expedition to the Maluku islands in December 1995, supported by COSTAI (Collaboration on Science and Technology Australia/ Indonesia), has provided the genetic base for a comprehensive tree improvement program on *M. cajuputi* in Indonesia. Further funding is now being sought to implement a breeding strategy and plan to ensure that planting stock of improved oil yielding capacity is available for the replanting program.

## Potential problems

### Weediness

When assessing the desirability of introducing and testing species of this group of genera in areas where they have not been grown previously, it is extremely important to consider the potential for their spread from cultivation to become noxious weeds. Characteristics of members of the genus that promote such events are early and heavy seeding, fast growth, adaptation to swampy environments including long periods of inundation, resistance to damage by fire and the ability to regenerate by coppicing and/ or root suckering. In Florida, conditions prevail that have allowed *M. quinquenervia* to invade natural wetlands and become a serious pest, crowding out regeneration of native plants and destroying wildlife habitat (Geiger 1981; NAS 1983).

### Propagation

Species of this group of genera generally produce extremely small seed. Inexperience in handling such seed often leads to failure in the nursery. The seed often germinates readily but the tiny seedlings are easily damaged by overhead watering or rain, or may be killed if the sowing mix dries.

A method of watering that avoids these problems is the "bog" technique. Here the germination tray stands permanently in water so that moisture soaks up to the surface which is constantly moist but not flooded. Seed is sown evenly over the surface at the recommended density. An inflated plastic bag may be fitted over the container to maintain a moist environment (Fig. 1.8). Once the germinants are sturdy enough to withstand overhead watering (ca. 4 weeks), the container should be removed from the water and handled normally. The risk of fungal disease is high, so good hygiene is essential.

**Figure 1.8** M. *cajuputi* propagation in Vietnam using the "bog" technique for germinating seeds.

After germination the tiny seedlings can be slow to develop at first, presumably while the roots establish. Once under way, however, they grow quickly and their total nursery period is similar to other fast growing species, such as eucalypts.

## Objectives of this report

The objectives of this report were two-fold:

- To evaluate and present data on the chemical composition and yields of essential oils of a broad range of tropical species of *Asteromyrtus*, *Callistemon* and *Melaleuca*.
- To identify species which, because of their oil composition and yield, may warrant further study with a view to commercial essential oil production.

An alphabetical listing of species by genus covered in this report is given in Table 1.2. These species have either all or part of their distribution north of the Tropic of Capricorn. Several other species also occur in this zone but were not sampled because of practical constraints. The missing species are: *A. tranganensis*, *C.* sp. nov. "Mt Spec", *C.* sp. nov. "Ravenshoe", *M. cornucopiae*, *M. dealbata* subsp. *glabrescens*, *M. nervosa* subsp. *crosslandiana*, *M. sericea* subsp. *gracilis*, thus leaving 1 species of *Asteromyrtus*, 4 species of *Callistemon* and several species and subspecies of *Melaleuca* still to be examined. The collection of samples mostly relied on botanists and foresters collecting the species on an opportunistic basis. Some species have received extensive treatment, while others received only limited study. Collection sites are given in Appendix 1.

**Table 1.2.** Alphabetical list of species by genus covered in this report including details of three unnamed species of *Melaleuca* (the names follow Wrigley and Fagg 1993).

| *Asteromyrtus* | *Callistemon* | *Melaleuca* |
|---|---|---|
| *angustifolia* | *polandii* | *acacioides* (two subsp.) |
| *arnhemica* | *recurvus* | *arcana* |
| *brassii* | *salignus* | *argentea* |
| *lysicephala* | *viminalis* | *bracteata* |
| *magnifica* | | *cajuputi* (three "subsp. ms") |
| *symphyocarpa* | | *cardiophylla* |
| | | *citrolens* |
| | | *dealbata* |
| | | *dissitiflora* |
| | | *foliolosa* |
| | | *lasiandra* |
| | | *leucadendra* |
| | | *linariifolia* |
| | | *linophylla* |
| | | *minutifolia* (two subsp.) |
| | | *nervosa* |
| | | *quinquenervia* |
| | | *saligna* |
| | | *sericea* |
| | | *stenostachya* |
| | | *tamariscina* (two subsp.) |
| | | *trichostachya* |
| | | *viridiflora* |
| | | *M.* sp. "Bukbuluk" |
| | | *M.* sp. "Cook District" |
| | | *M.* sp. "Laura" |

# Experimental

The leaves, when they arrived at the laboratory were weighed and, if they could not be steam distilled immediately, were allowed to air dry. It was found that in the vast majority of cases, even when the leaf material had to come from the Northern Territory, it arrived at the laboratory within 24 hours of dispatching.

The isolation of the oil from the leaves was achieved by steam distillation with water cohobation of the leaf material (approximately 100 g) in a Dean and Stark apparatus which was modified to give lower phase return of the water (Fig. 2.1). The time of steam distillation varied according to the composition of the oil being distilled from the leaves. For leaves containing only 1,8-cineole or monoterpene hydrocarbons the distillation time was approximately 4–6 hours, while for oils containing more oxygenated monoterpenes or sesquiterpene hydrocarbons the time required was approximately 8 hours. For oils containing a large amount of sesquiterpene alcohols etc. the time required for complete distillation of the oils was longer, ranging up to 24 hours. In all cases the steam distillation was carried out till no more oil appeared to be being produced.

**Figure 2.1** Dean and Stark glass still used in the steam distillation of leaves.

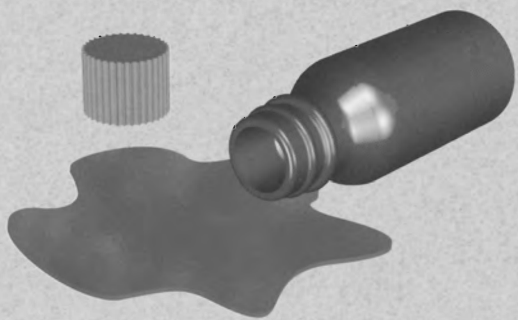
Once the distillation was complete a small amount (approximately 2–5 mL) of pentane was added to the oil to increase its volume, and the oil and water in the side arm of the apparatus separated. The pentane/oil solution was dried over anhydrous sodium sulfate, the solution transferred to another container and the pentane allowed to evaporate overnight. The oil yield was calculated on the weight of oil now remaining and the weight of leaf material on which the distillation was carried out, and quoted as a percentage yield on fresh, air-dry or oven-dry weight.

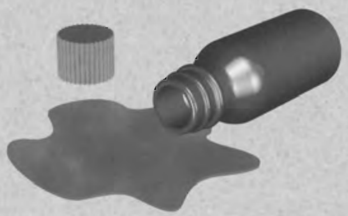
The oils were analysed by both gas–liquid chromatography (GLC) and combined gas–liquid chromatography/mass spectrometry (GC/MS). GLC was performed on either a polar phase SCOT column (85 m × 0.5 mm, SP1000) or a non polar phase SCOT column (30 m × 0.5 mm, OV1), temperature programmed with helium as carrier gas. The vast majority of oils were analysed on the polar column only. Combined GC/MS was carried out on one of two mass spectrometers. One was an AEI MS12 mass spectrometer connected to the Shimadzu GC6 AMP gas chromatograph through a heated all glass straight split interface. The mass spectrometer was operated in the electron impact mode at 70eV ionising voltage, 8000V accelerating potential and ion source temperature of 200°C. Spectra produced at 3 sec/decade scan rate were recorded every 6 seconds and acquired and processed by a VG Display Digispec data system. The second system used was a VG Quattro triple quadrupole mass spectrometer connected to a Hewlett Packard 5890 gas chromatograph. In this case the columns used were either a DB-Wax column (60 m × 0.32 mm) or a DB-5 column (30 m × 0.32 mm). Integrations of the GLC traces were achieved on either a Milton Roy CI 10 electronic integrator or a SMAD Integrator (Morgan-Kennedy Inc.).

Components of the various oils were identified using their identical GLC retention times with known compounds (either synthetic or from identified natural oils) and by comparison of their mass spectra with either known compounds or published spectra (Stenhagen et al. 1974; Heller and Milne 1978, 1980, 1983).

In the sections that follow, the percentages of compounds in various oils are taken from one representative tree or chemotype of that species. Analyses are given to 0.1%. A percentage listed as "tr" indicates that the component was present at less than 0.1%. Where a compound was present in an oil but its identity could not be determined it was included only if it was present in amounts greater than 0.1%.

# Species Digests





# *Asteromyrtus angustifolia*

*A. angustifolia* is a shrub or small tree to 10 m tall with long fine leaves and fibrous, slightly flaky bark. The species occurs on Cape York Peninsula and as far south as the Cooktown area, on sandy soils in low forest-heath or eucalypt woodland and occasionally in coastal monsoon forest. It has not been widely cultivated and the range of potential uses for this species are unknown.

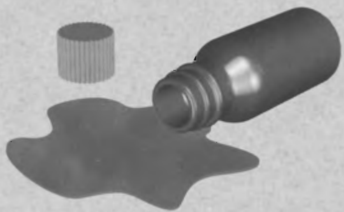
*A. angustifolia* contained an oil in which the major components were α-pinene (10–13%), 1,8-cineole (31–35%), β-caryophyllene (21–23%), α-humulene (1–3%), α-terpineol (7–8%) and δ-cadinene (3–4%). There were numerous other mono and sesquiterpenes present in small (<2%) amounts. In this species there was also a large number of sesquiterpene alcohols present in less than 1% amounts. One individual tree of *A. angustifolia* contained significantly less α-pinene (3%) and 1,8-cineole (21%) and a concomitantly greater amount of β-caryophyllene (43%). All other compounds were present in amounts similar to the rest of the samples.

Oil yield (based on air-dry weight): 1.6–2.1%.

Oil use: No use is foreseen for this oil.

Additional information on oils: Brophy et al. (1994).

| Compound | % |
|---|---|
| α-pinene | 10.3 |
| α-fenchene | tr |
| camphene | 0.1 |
| β-pinene | 0.5 |
| myrcene | 0.6 |
| α-terpinene | 0.2 |
| limonene | 1.5 |
| 1,8-cineole | 31.4 |
| γ-terpinene | 1.7 |
| E-β-ocimene | 0.1 |
| *p*-cymene | 0.2 |
| terpinolene | 0.4 |
| $C_{15}H_{24}$ | 0.2 |
| α-copaene | 0.4 |
| linalool | 0.2 |
| terpinen-4-ol | 0.5 |
| β-caryophyllene | 22.5 |
| aromadendrene | 0.1 |
| *cis*-menth-2-en-1-ol | 0.1 |
| δ-elemene | 0.1 |
| alloaromadendrene | 0.1 |
| humulene | 2.5 |
| viridiflorene | 1.3 |
| α-terpineol | 7.0 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{24}$ | 0.7 |
| $C_{15}H_{24}$ | 0.3 |
| α-muurolene | 0.6 |
| δ-cadinene | 3.1 |
| $C_{15}H_{24}$ | 0.1 |
| cadina-1,4-diene | 0.2 |
| $C_{15}H_{24}$ | 0.2 |
| germacrene-B | tr |
| calamenene | 0.2 |
| a calacorene | 0.5 |
| $C_{15}H_{26}O$ | 0.1 |
| caryophyllene oxide | 1.4 |
| ledol | 0.7 |
| $C_{15}H_{26}O$ | 0.6 |
| globulol | 0.9 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 1.2 |
| $C_{15}H_{26}O$ | 1.4 |
| T-cadinol | 1.1 |
| T-muurolol | 0.7 |
| δ-cadinol | 0.7 |
| $C_{15}H_{26}O$ | 0.6 |
| $C_{15}H_{26}O$ | 0.9 |
| α-cadinol | 1.2 |
| E,E-farnesol | 0.7 |
| $C_{15}H_{24}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.2 |



# *Asteromyrtus arnhemica*

*A. arnhemica* is a shrub or small tree to 5 m tall with narrowly elliptic leaf blade and with hard, fissured, fibrous bark. It has a very narrow natural distribution and occurs on sandy banks of gorges in the South and East Alligator River systems of the Northern Territory. Its performance and range of potential uses in cultivation are unknown.

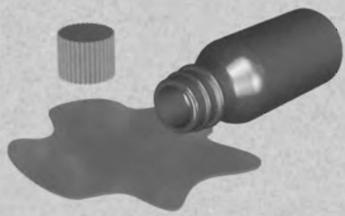
The essential oil from *A. arnhemica* was characterised by a large amount of α-pinene (86–92.4%). There were small (<2%) quantities of limonene, 1,8-cineole and α-terpineol. The total amount of sesquiterpenes present accounted for less than 5% of the oil.

Oil yield (based on air-dry weight): 0.5–1.4%.

Oil use: The oil has a pleasant smell because of its high pinene content, but its low oil yield means that commercial production is unlikely.

Additional information on oils: Brophy et al. (1994)

| Compound | % |
|---|---|
| α-pinene | 92.4 |
| α-fenchene | tr |
| camphene | 0.2 |
| β-pinene | 0.6 |
| myrcene | 0.1 |
| α-terpinene | 0.1 |
| limonene | 1.5 |
| 1,8-cineole | 1.3 |
| Z-β-ocimene | tr |
| γ-terpinene | 0.1 |
| *p*-cymene | 0.1 |
| terpinolene | 0.1 |
| linalool | tr |
| *trans*-menth-2-en-1-ol | tr |
| fenchone | 0.1 |
| terpinen-4-ol | tr |
| β-caryophyllene | 0.2 |
| aromadendrene | tr |
| alloaromadendrene | 0.1 |
| humulene | 0.4 |
| *cis*-piperitol | tr |
| α-terpineol | 0.8 |
| borneol | 0.4 |
| δ-cadinene | tr |
| $C_{15} H_{24}$ | 0.1 |
| $C_{15} H_{26} O$ | 0.2 |
| a calacorene | tr |
| $C_{15} H_{26} O$ | 0.4 |
| spathulenol | tr |
| E,E-farnesol | 0.2 |



# *Asteromyrtus brassii*

*A. brassii* is usually a shrub or small tree 3–9 m but may reach 25 m in height in some locations. The hard bark is brown or dark grey, fibrous with longitudinal fissures. The upright branches form a dense rounded crown. In Australia this species is restricted to the northeastern part of Cape York Peninsula as far south as the McIlwraith Range. It is also found in the Western Province of Papua New Guinea, and probably extends into Irian Jaya. *A. brassii* is used locally in Papua New Guinea for posts, poles and firewood (B.V. Gunn, pers. comm.). It has potential for shelter and soil conservation planting in tropical areas on difficult sites which range from infertile rocky ridges to sub-saline conditions adjacent to mangroves.

The oil obtained from *A. brassii* differed from the oils of the other *Asteromyrtus* species in that it contained a significantly greater quantity of γ-terpinene. The principal components of the oil of this

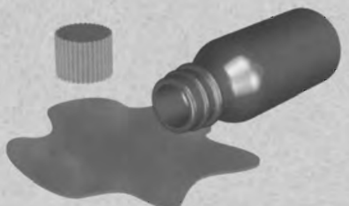
species were α-pinene (6–8%), limonene (1–5%), 1,8-cineole (24–46%), γ-terpinene (15–34%), terpinen-4-ol (3–5%), β-caryophyllene (3–8%), α-terpineol (2.1%) and viridiflorol (1–6%). There were also many sesquiterpenes (mostly alcohols) present in the oil in small (<0.5%) amounts. The bulk sample contained a significant amount of E-nerolidol (14%). This quantity was not represented in the oils of individual trees examined (0.3–0.9%) and it suggests that one or more trees in the bulk collection may be of a different chemotype.

Oil yield (based on air-dry weight): 1.0–1.4%.

Oil use: The composition of the oil suggests that it may be useful locally (e.g. in Papua New Guinea) as a general antiseptic.

Additional information on oils: Brophy et al. (1994).

| Compound | % |
|---|---|
| α-pinene | 6.0 |
| α-fenchene | tr |
| camphene | 0.1 |
| β-pinene | 0.3 |
| sabinene | tr |
| myrcene | 0.9 |
| α-terpinene | 0.8 |
| limonene | 1.2 |
| 1,8-cineole | 24.4 |
| Z-β-ocimene | 1.0 |
| γ-terpinene | 21.0 |
| *p*-cymene | 2.1 |
| terpinolene | 1.0 |
| α-*p*-dimethylstyrene | tr |
| $C_{15}H_{24}$ | tr |
| α-copaene | 0.2 |
| α-gurjunene | 0.1 |
| linalool | 0.3 |
| *trans*-menth-2-en-1-ol | tr |
| fenchone | 0.1 |
| $C_{10}H_{18}O$ | 0.1 |
| terpinen-4-ol | 3.3 |
| β-caryophyllene | 4.4 |
| aromadendrene | 0.3 |
| α-bulnesene | tr |
| *cis*-menth-2-en-1-ol | tr |
| alloaromadendrene | 0.2 |
| unknown | 0.1 |
| humulene | 1.2 |
| *cis*-piperitol | 0.1 |
| viridiflorene | 0.5 |
| α-terpineol | 2.1 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{24}$ | 0.3 |
| $C_{15}H_{24}$ | 0.2 |
| α-muurolene | 0.4 |
| δ-cadinene | 1.3 |
| γ-cadinene | tr |
| cadina-1,4-diene | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| calamenene | 0.1 |
| a calacorene | 0.5 |
| caryophyllene oxide | 0.4 |
| E-nerolidol | 13.7 |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | 0.2 |
| epiglobulol | 0.3 |
| ledol | 0.2 |
| globulol | 0.8 |
| viridiflorol | 5.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.3 |
| spathulenol | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.5 |
| T-cadinol | 0.5 |
| T-muurolol | 0.3 |
| δ-cadinol | 0.4 |
| α-cadinol | 0.6 |
| $C_{15}H_{26}O$ | 0.1 |



# *Asteromyrtus lysicephala*

## Kennedy's heath

*A. lysicephala* occurs mainly as a shrub to 3 m tall by 1.5 m across, and rarely as a small tree to 13 m. It has small leaves and the smallest flowers in the genus. It occurs in a variety of habitats and soils in far northern Queensland, southern Papua New Guinea and in Irian Jaya and on adjacent Aru Island in Indonesia. These include heathlands, open woodlands and seasonally inundated monsoon forests with soils ranging from sands to clays. It is adaptable under cultivation and is sometimes used as an ornamental as far south as northern New South Wales.

The oil obtained from *A. lysicephala* was characterised by the presence of α-pinene (11–14%), 1,8-cineole (47–51%), α-terpineol (0.1–4%), α-terpinyl acetate (3.8–5%) and β-caryophyllene (5–9.3%). There were lesser amounts (<2%) of limonene, γ-terpinene, terpinen-4-ol, δ-elemene and caryophyllene oxide. The

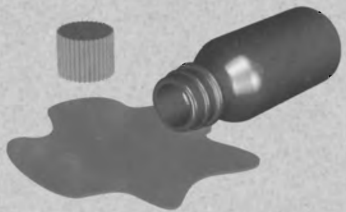
quantity of β-pinene varied somewhat (1–10%). There were a large number of sesquiterpenes present but they did not represent a significant proportion of the oil (<5%).

Oil yield (based on air-dry weight): 0.7–2.3%.

Oil use: The higher cineole varieties could produce a "Cajuput" type oil.

Additional information on oils: Brophy et al. (1994).

| Compound | % |
|---|---|
| α-pinene | 11.2 |
| α-fenchene | 0.1 |
| camphene | 0.1 |
| β-pinene | 4.4 |
| sabinene | tr |
| myrcene | 0.6 |
| α-terpinene | 0.2 |
| limonene | 2.0 |
| 1,8-cineole | 48.8 |
| Z-β-ocimene | tr |
| γ-terpinene | 1.3 |
| E-β-ocimene | 0.4 |
| *p*-cymene | 0.6 |
| terpinolene | 0.4 |
| α-*p*-dimethylstyrene | tr |
| $C_{15}H_{24}$ | tr |
| α-copaene | 0.1 |
| α-gurjunene | tr |
| linalool | 0.1 |
| *trans*-*p*-menth-2-en-1-ol | tr |
| fenchone | 0.1 |
| $C_{10}H_{18}O$ | tr |
| terpinen-4-ol | 1.2 |
| β-caryophyllene | 9.3 |
| aromadendrene | 0.3 |
| α-bulnesene | tr |
| *cis*-menth-2-en-1-ol | 0.1 |
| δ-elemene | 0.4 |
| alloaromadendrene | 0.1 |
| $C_{10}H_{18}O$ | 0.5 |
| humulene | 0.8 |
| *cis*-piperitol | tr |
| viridiflorene | tr |
| α-terpineol | 2.7 |
| α-terpinyl acetate | 3.8 |
| α-muurolene | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| δ-cadinene | 0.2 |
| γ-cadinene | tr |
| cadina-1,4-diene | 0.4 |
| $C_{15}H_{24}$ | 0.1 |
| germacrene-B | 0.5 |
| calamenene | tr |
| a calacorene | 0.1 |
| caryophyllene oxide | 1.0 |
| E-nerolidol | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| epiglobulol | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| globulol | 0.8 |
| viridiflorol | 0.3 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.2 |
| spathulenol | 0.5 |
| T-cadinol | 0.5 |
| $C_{15}H_{26}O$ | 0.1 |
| α-cadinol | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| E,E-farnesol | 1.2 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{24}O$ | 0.3 |



## *Asteromyrtus magnifica*

*A. magnifica* is a slender small shrub to 3 m in height and 1.5 m in spread. It has rough brown fibrous bark and showy cream to yellow globular flower heads. The species has a narrow distribution occurring amongst dissected rocky outcrops and beside seasonal streams on sandstone plateau in Arnhem Land and on Groote Eylandt and adjacent islands of the Northern Territory. The species has considerable ornamental potential.

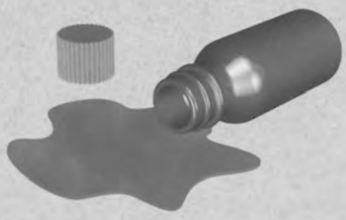
*A. magnifica* produced an oil in which the major components were α-pinene (14%), β-pinene (20%) and 1,8-cineole (34–36%). These three compounds were accompanied by lesser amounts of limonene (2.6%), γ-terpinene (3%), terpinen-4-ol (2%), β-caryophyllene (4.6%), α-terpineol (4%), caryophyllene oxide (1.2%), spathulenol (0.85–2%) and α-, β- and γ-eudesmols (total 2.5%).

Oil yield (based on air-dry weight): 2.6–2.7%.

Oil use: A higher cineole source could produce a "Cajuput" type oil.

Additional information on oils: Brophy et al. (1994).

| Compound | % |
|---|---|
| α-pinene | 14.1 |
| α-fenchene | tr |
| camphene | 0.3 |
| β-pinene | 19.8 |
| myrcene | 0.7 |
| α-terpinene | 0.5 |
| limonene | 2.6 |
| 1,8-cineole | 35.9 |
| γ-terpinene | 2.8 |
| *p*-cymene | 0.7 |
| terpinolene | 0.6 |
| linalool | 0.4 |
| *trans-p*-menth-2-en-1-ol | tr |
| fenchone | 0.1 |
| $C_{10}H_{18}O$ | 0.1 |
| terpinen-4-ol | 2.0 |
| β-caryophyllene | 4.7 |
| aromadendrene | 0.3 |
| α-bulnesene | tr |
| *cis*-menth-2-en-1-ol | tr |
| alloaromadendrene | 0.1 |
| humulene | 0.5 |
| *cis*-piperitol | tr |
| viridiflorene | 0.1 |
| α-terpineol | 3.9 |
| δ-cadinene | 0.1 |
| γ-cadinene | 0.1 |
| calamenene | 0.1 |
| a calacorene | 0.1 |
| caryophyllene oxide | 1.2 |
| E-nerolidol | 0.1 |
| epiglobulol | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 0.7 |
| viridiflorol | 0.1 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{24}O$ | 0.2 |
| spathulenol | 0.9 |
| γ-eudesmol | 0.4 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| α-eudesmol | 0.9 |
| β-eudesmol | 1.2 |
| E,E-farnesol | 0.4 |
| $C_{15}H_{24}O$ | 0.2 |



# *Asteromyrtus symphyocarpa*

## Liniment tree

*A. symphyocarpa* occurs as a multi-stemmed shrub or small tree in Australia, usually in the height range of 3–12 m, but may reach larger dimensions in Papua New Guinea. This species is adapted to acidic, infertile and periodically waterlogged soils in the lowland tropics. It occurs in the Northern Territory and far northern Queensland. It extends to southern Papua New Guinea and Irian Jaya in Indonesia. Potential uses include fuelwood, small round timbers, erosion control and revegetation of mining areas.

The oil obtained from *A. symphyocarpa* had as principal components α-pinene (16–18%) and 1,8-cineole (39–43%). These were accompanied by lesser amounts of limonene (2%), γ-terpinene (4%), *p*-cymene (2%), terpinen-4-ol (5–6%), β-caryophyllene (4–6%),

α-terpineol (3%), globulol (1.6%), spathulenol (1%) and α-, β- and γ-eudesmols (total 3–6%).

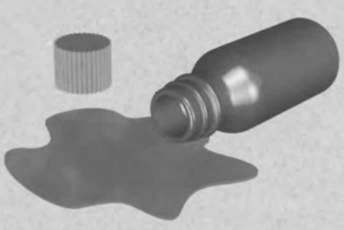
This species, under the name *Melaleuca symphyocarpa*, has been the subject of a previous report (Brophy et al. 1990), in which the trees examined came from five different sites on Cape York Peninsula and in the Northern Territory. The oil obtained from those trees was both qualitatively and quantitatively similar to that reported here. It differed principally in containing less α-pinene (8–16%), terpinen-4-ol (0.4–1%) and α-, β- and γ-eudesmols (not detected), and containing more 1,8-cineole (45–68%) and β-caryophyllene (4–19%). It can be inferred from the overall data that the oil composition remains relatively constant throughout the geographic range of this species.

Oil yield (based on air-dry weight): 2–2.5%.

Oil use: This species could produce a "Cajuput" type oil.

Additional information on oils: Brophy et al. (1988, 1989, 1994).

| Compound | % |
|---|---|
| α-pinene | 17.1 |
| camphene | tr |
| β-pinene | 1.4 |
| sabinene | tr |
| myrcene | 0.8 |
| α-terpinene | 1.4 |
| limonene | 1.7 |
| 1,8-cineole | 40.1 |
| γ-terpinene | 3.8 |
| *p*-cymene | 1.6 |
| terpinolene | 0.7 |
| α-copaene | tr |
| α-gurjunene | 0.9 |
| *trans-p*-menth-2-en-1-ol | 0.1 |
| fenchone | tr |
| terpinen-4-ol | 4.7 |
| β-caryophyllene | 5.1 |
| aromadendrene | 0.4 |
| α-bulnesene | tr |
| *cis*-menth-2-en-1-ol | 0.1 |
| alloaromadendrene | 0.7 |
| humulene | 0.7 |
| viridiflorene | 0.1 |
| α-terpineol | 3.4 |
| borneol | 0.1 |
| δ-cadinene | 0.2 |
| γ-cadinene | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| cadina-1,4-diene | tr |
| calamenene | tr |
| caryophyllene oxide | 0.6 |
| E-nerolidol | 0.4 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| epiglobulol | 0.4 |
| globulol | 1.6 |
| viridiflorol | 0.3 |
| $C_{15}H_{26}O$ | 2.3 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.5 |
| spathulenol | 0.9 |
| γ-eudesmol | 1.3 |
| $C_{15}H_{26}O$ | 0.1 |
| α-eudesmol | 1.1 |
| β-eudesmol | 1.0 |
| $C_{15}H_{26}O$ | 0.5 |
| E,E-farnesol | 0.1 |
| $C_{15}H_{24}O$ | 0.1 |



## *Callistemon polandii*

### Gold-tipped bottlebrush

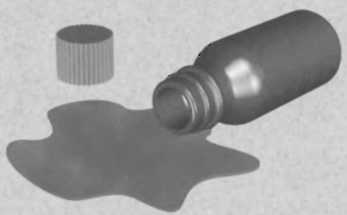
*C. polandii* is a medium-sized to tall shrub, 1.5–3 m in height and 1–3 m breadth, of the mountain slopes of the central coast and northeastern Queensland. It grows naturally in rock crevices in soils of high organic content. The species is a popular ornamental in tropical gardens because of its large leaves and large flower spikes of red with yellow anthers. Several cultivars selected for ornamental attributes are available from Queensland nurseries.

The main components of the oil of *C. polandii* were the sesquiterpenes β-caryophyllene (29%), humulene (22%) and caryophyllene oxide (14%). There was also 8% of an unidentified monoterpene derivative and 2% of *p*-cymene. The essential oil of this species differed from most other *Callistemon* oils (not included in this report) in that it did not contain 1,8-cineole as its major component.

Oil yield (based on fresh weight): 0.01%.

Oil use: The essential oil of *C. polandii* was produced in negligible yield.

| Compound | % |
|---|---|
| α-pinene | 0.2 |
| camphene | tr |
| β-pinene | 0.1 |
| sabinene | tr |
| myrcene | 0.1 |
| limonene | 0.2 |
| 1,8-cineole | 0.1 |
| Z-β-ocimene | 0.1 |
| E-β-ocimene | 0.3 |
| *p*-cymene | 2.0 |
| terpinolene | 0.1 |
| nonanal tent | 0.2 |
| linalool | tr |
| an alkanol | 0.1 |
| *trans*-menth-2-en-1-ol | tr |
| pinocarvone | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| β-caryophyllene | 28.2 |
| terpinen-4-ol | 0.3 |
| aromadendrene | 0.2 |
| *cis*-menth-2-en-1-ol | tr |
| $C_{15}H_{24}$ | 0.2 |
| humulene | 21.7 |
| unknown, mw174 | 0.7 |
| α-terpineol | 0.8 |
| unknown, mw 236 | 0.3 |
| $C_{15}H_{24}O$ | 0.2 |
| *p*-cymene-8-ol | 0.1 |
| geranyl acetate | 0.2 |
| benzyl alcohol | tr |
| $C_{15}H_{24}O$ | 0.4 |
| unknown, mw192 | 0.2 |
| $C_{15}H_{24}O$ | 1.4 |
| caryophyllene oxide | 13.5 |
| methyleugenol | 0.7 |
| $C_{15}H_{24}O$ | 0.4 |
| unknown, C10 dtve | 7.8 |
| $C_{15}H_{24}O$ | 0.8 |
| $C_{15}H_{24}O$ | 0.3 |
| $C_{15}H_{24}O$ | 1.3 |
| $C_{15}H_{24}O$ | 1.0 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.9 |
| $C_{15}H_{26}O$ | 2.6 |
| $C_{15}$ compounds | 10 |



## *Callistemon recurvus*

### Tinaroo bottlebrush

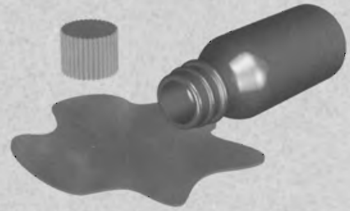
A shrub or small, straggly tree with a range in height of 1 to 7 m. Tinaroo bottlebrush occurs in open forest on granitic soils along soaks on rocky slopes and gullies of the Atherton Tablelands in northern Queensland. Small forms make popular garden specimens.

*C. recurvus* produced an essential oil in which the major component was 1,8-cineole (70%). This was accompanied by lesser amounts of the monoterpene hydrocarbons α-pinene (4%), and limonene (5%) and the alcohols, terpinen-4-ol (2%) and α-terpineol (9%). Sesquiterpenes did not account for significant amounts of oil. The major compounds were β-caryophyllene (2%), caryophyllene oxide (1%), globulol (1%) and spathulenol (2%).

Oil yield (based on fresh weight): 0.8%

Oil use: The oil yield is too low for any commercial use.

| Compound | % |
|---|---|
| α-pinene | 3.8 |
| camphene | 0.1 |
| β-pinene | 1.0 |
| myrcene | 0.3 |
| α-terpinene | 0.1 |
| limonene | 4.2 |
| 1,8-cineole | 69.1 |
| γ-terpinene | 0.1 |
| E-β-ocimene | 0.1 |
| *p*-cymene | 0.7 |
| terpinolene | 0.1 |
| linalool | 0.1 |
| pinocarvone | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| terpinen-4-ol | 1.3 |
| β-caryophyllene | 1.3 |
| alloaromadendrene | 0.2 |
| *trans*-pinocarveol | 0.1 |
| humulene | 0.1 |
| δ-terpineol | 0.1 |
| α-terpineol | 8.4 |
| caryophyllene oxide | 1.0 |
| globulol | 0.6 |
| viridiflorol | 0.5 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| spathulenol | 1.5 |
| $C_{15}$ compounds | 1 |



# *Callistemon salignus*

## Willow bottlebrush

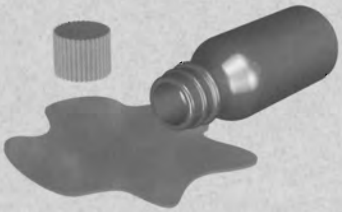
*C. salignus* may be found as a small tree to 10 m with pendulous branches and papery bark. It occurs in coastal New South Wales and in southeastern Queensland on low-lying river flats and creek banks. It is popular as a park or street tree in coastal areas. Several pink flowering cultivars are available in the nursery trade.

The leaf essential oil obtained from *C. salignus* had as its main component 1,8-cineole (22–53%). Other compounds of significance in the oil were linalool (5–31%), limonene (2–4%), α-pinene (1%), α-phellandrene (1%), *p*-cymene (2–6%), α-terpineol (6–13%), caryophyllene oxide (0.4–2%) and spathulenol (1–4%). There were over 50 compounds detected in the essential oil, but apart from 1,8-cineole, the vast majority were present in amounts of less than 1%.

Oil yield (based on fresh weight): 0.2–0.8%.

Oil use: There is no foreseeable use for this oil.

| Compound | % |
|---|---|
| α-pinene | 1.0 |
| α-thujene | 0.2 |
| α-fenchene | tr |
| camphene | tr |
| β-pinene | 0.4 |
| an amyl acetate | 0.1 |
| sabinene | 0.1 |
| α-phellandrene | 1.0 |
| myrcene | 0.7 |
| α-terpinene | tr |
| limonene | 3.7 |
| 1,8-cineole | 53.0 |
| Z-β-ocimene | 0.2 |
| γ-terpinene | 1.1 |
| E-β-ocimene | 0.7 |
| *p*-cymene | 6.0 |
| terpinolene | 0.3 |
| $C_{10}H_{16}O$ | 0.1 |
| α-*p*-dimethylstyrene | 0.1 |
| *cis*-linalool oxide | 0.6 |
| *trans*-linalool oxide | 0.5 |
| α-copaene | 0.2 |
| camphor tent | 0.6 |
| linalool | 5.6 |
| β-elemene | 0.1 |
| β-caryophyllene | 0.6 |
| terpinen-4-ol | 1.0 |
| aromadendrene | 0.1 |
| a *hex*-3-enyl butyrate | 0.8 |
| alloaromadendrene | 0.1 |
| *trans*-pinocarveol | 0.1 |
| a $C_{10}$ acetate ..tent.. | 0.9 |
| $C_{15}H_{24}$ | 0.1 |
| α-terpineol | 6.2 |
| unknown, mw 212 | 0.2 |
| carvone | 0.3 |
| δ-cadinene | 0.2 |
| geranyl acetate | 0.2 |
| $C_{10}H_{16}O$ | 0.2 |
| $C_{10}H_{16}O$ | 0.5 |
| *p*-cymene-8-ol | 0.2 |
| phenylethyl acetate | 0.1 |
| $C_{10}H_{16}O$ | 0.1 |
| $C_{10}H_{16}O$ | 0.1 |
| palustrol | 0.1 |
| caryophyllene oxide | 0.4 |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| globulol | 0.5 |
| viridiflorol | 0.3 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| spathulenol | 0.7 |
| thymol/carvacrol | 0.6 |
| $C_{15}$ compounds | 5 |



# Callistemon viminalis

## Weeping bottlebrush

*C. viminalis* occurs as a large shrub or small tree to 10 m tall, with mostly pendulous branches. The bark is hard and furrowed. The natural distribution extends from northern New South Wales to Cape York Peninsula. The species is found along watercourses and favours granitic or sandstone soils. It is a most useful garden and street tree noted for its foliage and flowers in both tropical and warm-temperate climates. Many cultivars are available through the nursery trade.

*C. viminalis*, as a result of extensive sampling over its wide geographical range, has been shown to occur in two different chemical forms at its extremities, though there appears to be a gradation between these two forms in the centre of its distribution. One form is very high in 1,8-cineole while the other form contains roughly equivalent amounts of α- and β-pinene and 1,8-cineole as well as significant amounts of other mono- and sesquiterpenes. Preliminary analyses of the distributions of these two chemotypes have shown that

they also roughly correspond to the two varieties of *C. viminalis* described by Byrnes (1986). The type, *C. viminalis* var. *viminalis*, occurs from the northern extremity of its range, Kennedy Hill Gorge (12°28'S), to near Marlborough. This coincides with the low cineole oils. *C. viminalis* var. *minor* occurs in southeastern Queensland and into northern New South Wales. This variety coincides with the high cineole oils. Detailed analyses of the two chemotypes are given below.

Oil yield (based on fresh weight): 0.1–0.5%.

Oil use: The oil yield is too low for an economic use.

Additional information on oils: Brophy et al. (1985).

### *Chemotype I*

| Compound | % |
|---|---|
| α-pinene | 18.0 |
| camphene | 0.1 |
| β-pinene | 1.0 |
| sabinene | tr |
| myrcene | 0.3 |
| α-phellandrene | 0.1 |
| limonene | 5.4 |
| 1,8-cineole | 48.7 |
| γ-terpinene | 0.3 |
| *p*-cymene | 0.8 |
| terpinolene | tr |
| α-*p*-dimethylstyrene | tr |
| linalool | 0.5 |
| pinocarvone | tr |
| terpinen-4-ol | 0.9 |
| β-caryophyllene | 0.2 |
| aromadendrene | 0.1 |
| *trans*-pinocarveol | 0.3 |
| humulene | tr |
| α-terpineol | 11.8 |
| α-terpinyl acetate | 0.3 |
| bicyclogermacrene | tr |
| β-farnesene | 0.3 |
| geraniol | tr |
| caryophyllene oxide | 0.3 |
| globulol | 0.9 |
| viridiflorol | 0.6 |
| spathulenol | 0.1 |
| γ-eudesmol | 0.8 |
| α-eudesmol | 0.3 |
| β-eudesmol | 0.3 |

### *Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 11.5 |
| β-pinene | 0.9 |
| sabinene | tr |
| myrcene | 0.8 |
| limonene | 3.0 |
| 1,8-cineole | 70.3 |
| γ-terpinene | 0.3 |
| *p*-cymene | 1.7 |
| terpinolene | 0.2 |
| terpinen-4-ol | 0.4 |
| β-caryophyllene | 0.2 |
| *trans*-pinocarveol | 0.1 |
| α-terpineol | 7.7 |
| bicyclogermacrene | 0.1 |
| caryophyllene oxide | 0.1 |
| globulol | 1.0 |
| viridiflorol | 0.1 |
| spathulenol | tr |
| γ-eudesmol | 0.1 |
| α-eudesmol | 0.1 |
| β-eudesmol | tr |

# *Melaleuca acacioides* subsp. *acacioides*

## Flying fox tea tree

*M. acacioides* subsp. *acacioides* occurs as a shrub or small tree, 4–10 m tall, and may develop a multi-stemmed habit when open-grown. It is found in coastal and subcoastal (usually saline and seasonally flooded) habitats in far northern Queensland, the north of the Northern Territory, islands of the Torres Strait in Australia, and southern Papua New Guinea. It has potential for production of posts and small poles, fuelwood and windbreaks on difficult sites near the coast. This subspecies will soon be raised to species rank, as *M. acacioides* (L. Craven, pers. comm.) with no subspecies.

*M. acacioides* produced an essential oil, in low yield, which was almost entirely composed of sesquiterpenes. The main components were β-selinene (21–30%) and

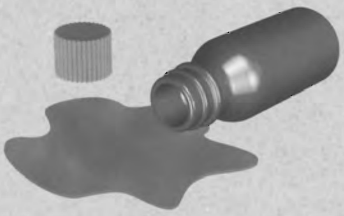
α-selinene (53–54%). The next most abundant compounds were selen-11-en-4-ol (6–8%), δ-cadinene (0.9–6%), β-caryophyllene (1–2%), globulol (0.7–1%) as well as some unidentified oxygenated sesquiterpenes in the range 0.1–3%. Monoterpenes were very poorly represented.

Oil yield (based on dry weight): 0.3–0.8%.

Oil use: The oil has a distinctive pleasant aroma which is associated with the sesquiterpene alcohol fraction. It would depend very much on the advice of perfumers if there is any commercial potential for this oil.

Additional information on oils: Brophy et al. (1987, 1989).

| Compound | % |
|---|---|
| ethylbenzene | tr |
| limonene | 0.1 |
| α-copaene | 0.1 |
| α-gurjunene | tr |
| β-caryophyllene | 1.2 |
| β-gurjunene | 0.1 |
| $C_{15}H_{24}$ | 2.02 |
| β-selinene | 21.4 |
| α-selinene | 53.9 |
| selina-3,7-diene | 0.6 |
| δ-cadinene | 2.3 |
| $C_{15}H_{24}O$ | 0.7 |
| $C_{15}H_{24}O$ | tr |
| $C_{15}H_{24}O$ | 0.1 |
| methyleugenol | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 0.7 |
| viridiflorol | 0.2 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 1.8 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| selina-11-en-4-ol | 6.2 |
| $C_{15}H_{24}O$ | tr |
| $C_{15}H_{24}O$ | tr |
| $C_{15}H_{24}O$ | 1.0 |
| E,E-farnesol | 3.9 |
| $C_{15}H_{24}O$ | 0.3 |
| $C_{15}H_{24}O$ | 0.1 |



# *Melaleuca acacioides* subsp. *alsophila*

## Coastal paperbark

Coastal paperbark usually occurs as a small tree to 10 m in height, sometimes multi-stemmed, with white papery bark. It is found in northwestern Australia and is common on river banks, on the margins of mud flats and in seasonally inundated saline depressions. Like the type, this subspecies has potential for production of posts and small poles, fuelwood and windbreaks on difficult sites near the coast. This subspecies will soon be raised to species rank, as *M. alsophila* (L. Craven, pers. comm.).

There appear to be two chemotypes of *M. acacioides* subsp. *alsophila*. One chemotype is rich in α-pinene and/or 1,8-cineole and gives a low oil yield, while the other chemotype contains significant amounts of neral/geranial and terpinen-4-ol and gives a higher oil yield.

Chemotype I contains α-pinene (2–65%) and 1,8-cineole (15–66%) as its major compounds, while there are significant amounts of limonene (1–3%),

E-β-ocimene (0.8–2%), pinocarvone (0.3–5%), and *trans*-pinocarveol (1–17%). Sesquiterpenes, while numerous, were of little consequence in this oil. The oil yield of this chemotype was 0.04–0.1% on a fresh weight basis.

The second chemotype contained major amounts of neral (2–10%), geranial (2–19%), terpinen-4-ol (13–32%), α-terpineol (1–7%), *p*-cymene (2–40%, the majority >20%) and geraniol (1–3%). The oil yield of this second chemotype was 0.1–0.6% on a fresh weight basis.

Trees from a further location appeared to be intermediate between these two chemotypes. In this case the major compounds were 1,8-cineole (28–39%), terpinen-4-ol (13–16%), α-terpineol (4–7%), E-methyl cinnamate (1–12%) and globulol (1–3%). The oil yield in this case was 1–1.6% on fresh leaves.

Oil yield (based on fresh weight): 0.04–1.6%.

Oil use: Chemotype II would make a useful lemon scented "Tea Tree Oil" if the oil yield could be improved.

Additional information on oils: Brophy et al. (1987, 1989).

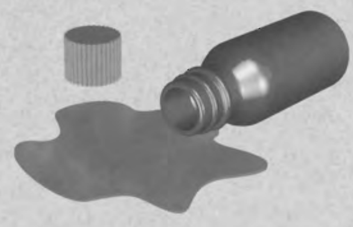
### *Chemotype I*

| Compound | % |
|---|---|
| isovaleric aldehyde | 0.2 |
| tricyclene | 0.6 |
| α-pinene | 65.0 |
| α-fenchene | 0.2 |
| camphene | 0.5 |
| β-pinene | 0.1 |
| sabinene | tr |
| myrcene | tr |
| α-phellandrene | tr |
| α-terpinene | 0.1 |
| limonene | 2.6 |
| 1,8-cineole | 15.1 |
| Z-β-ocimene | 0.2 |
| γ-terpinene | 0.3 |
| E-β-ocimene | tr |
| *p*-cymene | 0.8 |
| terpinolene | 0.2 |
| a-*p*-dimethylstyrene | tr |
| campholenic aldehyde | 0.2 |
| pinocamphone | 0.1 |
| pinocarvone | 0.3 |
| fenchone | 0.2 |
| terpinen-4-ol | 0.1 |
| β-caryophyllene | 0.2 |
| unknown | 0.2 |
| myrtenal | 0.3 |
| *trans*-pinocarveol | 1.8 |
| neral | tr |
| α-terpineol | 2.7 |
| borneol | 0.7 |
| verbenone | tr |
| carvone | tr |
| phenylpropanal tent | 0.7 |
| myrtenol | 0.1 |
| *trans*-mentha-1(7), 8-dien-2-ol | 0.1 |
| *trans*-mentha-1,8 -dien-6-ol | 0.4 |
| *p*-cymene-8-ol | 0.1 |
| 4-phenylbutanone | 0.1 |
| *cis*-mentha-1,8-dien-6-ol | 0.1 |
| *cis*-mentha-1(7),8-dien-2-ol | 0.1 |
| methyleugenol | 0.5 |

| | |
|---|---|
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 0.8 |
| viridiflorol | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.3 |
| spathulenol | 0.2 |
| $C_{15}H_{24}O$ | 0.3 |
| E,E-farnesol | tr |

### *Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 1.5 |
| β-pinene | 0.2 |
| sabinene | 0.3 |
| myrcene | 1.0 |
| α-terpinene | 1.0 |
| limonene | 1.3 |
| β-phellandrene | 0.4 |
| γ-terpinene | 4.8 |
| *p*-cymene | 13.2 |
| terpinolene | 0.4 |
| rose oxide | 0.4 |
| *cis*-linalool oxide | tr |
| *trans*-linalool oxide | 0.1 |
| α-*p*-dimethylstyrene | 0.1 |
| citronellal | 3.0 |
| linalool | 0.1 |
| isopulegol | 4.0 |
| *trans*-menth-2-en-1-ol | 8.2 |
| terpinen-4-ol | 31.4 |
| *cis*-menth-2-en-1-ol | 0.6 |
| acetophenone | 0.3 |
| unknown | 0.4 |
| neral | 4.6 |
| α-terpineol | 1.7 |
| geranial | 9.2 |
| $C_{10}H_{18}O$ | 0.2 |
| $C_{10}H_{18}O$ | 0.1 |
| citronellol | 8.5 |
| nerol | 0.4 |
| *p*-cymene-8-ol | 0.1 |
| geraniol | 1.2 |
| nerolidol | 0.1 |
| unknown $C_{10}$ compounds | 0.7 |



# *Melaleuca arcana*

## Winti

*M. arcana* is a shrub or small tree (1–12 m) of the hot humid tropics of northern Queensland. It tolerates infertile, often swampy, sites with acidic soils and can grow as dense, wind-sheared thickets on coastal sand dunes. It has potential for use in windbreaks, for sand stabilisation, fuelwood, posts and rails.

There seemed to be significant variation in the essential oils obtained from *M. arcana*, though all oils were monoterpenoid in character. Oil obtained from species/ provenance trials at Gympie, from seed obtained at Cooktown and Tozer's Gap (S14876, S14866) produced an oil in which α-pinene (26–50%) was the major component. There were lesser amounts of the hydrocarbons β-pinene (1–3%), sabinene (0.1–2%), α-terpinene (0.2–5%), limonene (4–8%) and γ-terpinene (0.6–11%) as well as the ether 1,8–cineole (1–40%). Oxygenated monoterpenes were dominated by the two alcohols α-terpineol (1–7%) and terpinen-4-ol (0.3–33%).

Sesquiterpenes, while numerous, were not present in great amounts. The principal compounds were β-caryophyllene (0.6–1%), humulene (0.2–0.5%), germacrene-D (0.3–2%), δ-cadinene (1–4%) and α-cadinol (0.1–2%). The oil yield from the Tozer's Gap material, on an air-dry leaf basis, was 0.6–1%, while that from Cooktown was 0.01%.

An oil sample from trees growing north of Wakoroka (JRC9761), as reported in detail here, contained terpinen-4-ol (23–33%) and 1,8-cineole (2–27%) as major monoterpenes, with citronellol (2–4%) also being present. The sesquiterpenes usually encountered in *Melaleuca* oils were present but in quantities of less than 3%. The oil yield from this source was 0.8–1.4% on a dry weight basis.

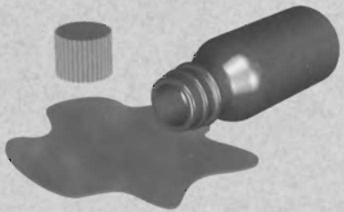
Oil yield (based on air-dry weight): 0.01–1.4%.

Oil use: No commercial use for the oil is foreseen.

Additional information on oils: Brophy et al. (1988, 1989).

| Compound | % |
|---|---|
| isovaleraldehyde | tr |
| α-pinene | 11.5 |
| camphene | tr |
| β-pinene | 2.2 |
| sabinene | 0.6 |
| myrcene | 1.6 |
| α-phellandrene | 0.5 |
| $C_{10}H_{16}$ | 0.4 |
| α-terpinene | 3.2 |
| limonene | 5.7 |
| 1,8-cineole | 8.9 |
| γ-terpinene | 7.1 |
| *p*-cymene | 5.4 |
| terpinolene | 1.5 |
| rose oxide | tr |
| mentha-1,3,8-triene | tr |
| mentha-1,4,8-triene | 0.1 |
| α-*p*-dimethylstyrene | 0.1 |
| α-cubebene | 0.2 |
| α-copaene | 0.2 |
| benzaldehyde | 0.2 |
| β-bourbonene | tr |
| linalool | 0.1 |
| an alkanol | 0.2 |
| *trans*-menth-2-en-1-ol | 1.2 |
| isopulegol | 0.9 |
| pinocamphone | 0.9 |
| terpinen-4-ol and β-caryophyllene | 23.7 |
| aromadendrene | 0.2 |
| *cis*-menth-2-en-1-ol | 0.4 |
| $C_{15}H_{24}$ | 0.2 |
| $C_{15}H_{24}$ | 0.1 |
| humulene | 0.3 |
| *cis*-piperitol | 0.1 |
| a muurolene | 0.4 |
| α-terpineol | 3.7 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{24}$ | 0.2 |
| a muurolene | 0.3 |
| *trans*-piperitol | 0.2 |
| δ-cadinene | 0.9 |
| γ-cadinol | 0.1 |
| citronellol | 2.9 |
| myrtenol | 0.6 |
| calemenene | 0.1 |
| *p*-cymene-8-ol | 0.7 |
| a menth-2-en-7-ol tent | 0.1 |

| | | | | | |
|---|---|---|---|---|---|
| a menth-2-en-7-ol...tent | 1.0 | $C_{15}H_{26}O$ | 0.1 | $C_{15}H_{26}O$ | 0.3 |
| calacorene | 0.1 | $C_{15}H_{26}O$ | 0.2 | $C_{15}H_{24}O$ | 0.5 |
| palustrol | 0.1 | spathulenol | 1.9 | α-cadinol | 1.4 |
| caryophyllene oxide | 0.1 | $C_{15}H_{26}O$ | 0.4 | $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.4 | $C_{15}H_{26}O$ | 0.2 | $C_{15}H_{24}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.3 | T-cadinol | 0.4 | $C_{15}H_{22}O$ | 0.2 |
| globulol | 0.6 | T-muurolol | 0.9 | $C_{15}H_{24}O$ | 0.2 |
| viridiflorol | 0.4 | δ-cadinol | 0.3 | $C_{15}H_{24}O$ | 0.3 |



## *Melaleuca argentea*

### Silver-leaved paperbark

*M. argentea* usually occurs as a spreading tree to 25 m tall with slender pendulous branchlets, creamy white to grey papery bark and foliage that turns silvery-green seasonally. The map gives the approximate boundaries of the species in northern Australia, excluding the Queensland occurrence of the proposed new species, *M.* sp. "Laura", soon to be separated from *M. argentea* (L. Craven, pers. comm.). *M. argentea* is found commonly along banks of freshwater creeks and rivers in deep sandy or sandy-loam soils that have a clay substrate. The species has potential for posts, poles, fuelwood, honey, ornament and shelter.

The essential oil obtained from *M. argentea* contained a mixture of mono- and sesquiterpenes with approximately equal contributions from both classes. There appeared to be several chemotypes involved, one of which was mainly monoterpenoid and the others being sesquiterpene dominated.

The main monoterpenes detected in the oil were the hydrocarbons α-pinene (0.3–20%), β-pinene (0.2–3%), sabinene (6–19%), myrcene (1–3%), α-terpinene (3–6%), limonene (3–4%), γ-terpinene (7–10%) and terpinolene (1–3%), together with the ether 1,8-cineole (2–26%). Of the oxygenated monoterpenes, the main members were terpinen-4-ol (13–18%), α-terpineol (0.2–7%) and terpinyl acetate (0.5–5%) as well as small and varying quantities of the two sabinene hydrates and the two menth-2-en-1-ols.

In the chemotype that was monoterpene-dominated the principal sesquiterpenes were globulol (0.4–7%), viridiflorol (0.1–2%), spathulenol (0.1–3%) and bicyclogermacrene (0.1–5%). An unusual feature of this oil was the presence of E-methyl cinnamate (0.5–4%) in the steam distillate.

The second chemotype of *M. argentea* encountered contained large quantities of E-nerolidol (88–92%) as its principal component. E-methyl cinnamate (0.7–5%) was also identified. There appeared to be no observable difference in oil yield between the chemotypes.

Oil yield (based on fresh weight): 0.1–1.2%.

Oil use: No commercial use of this oil is foreseen because of the low yields.

### Chemotype I

| Compound | % |
|---|---|
| α-pinene | 3.6 |
| β-pinene | 1.6 |
| sabinene | 8.7 |
| myrcene | 2.2 |
| α-phellandrene | tr |
| α-terpinene | 5.3 |
| limonene | 3.8 |
| 1,8-cineole | 9.8 |
| γ-terpinene | 10 |
| E-β-ocimene | tr |
| *p*-cymene | 1.6 |
| terpinolene | 2.2 |
| α-*p*-dimethylstyrene | tr |
| α-cubebene | tr |
| bicycloelemene | 0.6 |
| $C_{15}H_{24}$ | tr |
| benzaldehyde | tr |
| α-gurjunene | 0.1 |
| linalool | 0.3 |
| *trans*-menth-2-en-1-ol | 1.0 |
| $C_{10}H_{18}O$ | 0.1 |
| β-elemene | 0.2 |
| terpinen-4-ol | 17.2 |
| β-caryophyllene | 0.3 |
| aromadendrene | 1.0 |
| α-bulnesene | 0.1 |
| methyl benzoate | tr |
| *cis*-menth-2-en-1-ol | 0.6 |
| alloaromadendrene | 0.4 |
| *cis*-piperitol | 0.2 |
| viridiflorene | 0.2 |
| α-terpineol | 2.3 |
| terpinyl acetate | 3.0 |
| β-selinene | 0.1 |
| α-selinene | 0.2 |
| bicyclogermacrene | 3.6 |

| | |
|---|---|
| *trans*-piperitol | 0.4 |
| δ-cadinene | 0.1 |
| citronellol | 2.4 |
| $C_{15}H_{22}$ | 0.2 |
| an amyl benzoate | tr |
| palustrol | 0.1 |
| an amyl benzoate | 0.1 |
| $C_{15}H_{26}O$ | 1.1 |
| $C_{15}H_{26}O$ | 0.8 |
| an amyl benzoate | 0.1 |
| $C_{15}H_{26}O$ | 1.3 |
| nerolidol | 0.7 |
| $C_{15}H_{26}O$ | 1.7 |
| E-methyl cinnamate | 2.8 |
| globulol | 3.6 |
| viridiflorol | 1.0 |
| $C_{15}H_{26}O$ | 2.0 |
| $C_{15}H_{26}O$ | 2.1 |
| spathulenol | 2.3 |
| $C_{15}H_{24}O$ | tr |
| T-cadinol | tr |
| T-muurolol | tr |
| $C_{15}H_{24}O$ | tr |
| δ-cadinol | tr |
| $C_{15}H_{24}O$ | tr |
| α-cadinol | tr |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | tr |
| farnesol | tr |
| $C_{15}H_{24}O$ | tr |

### Chemotype II

| Compound | % |
|---|---|
| α-pinene | 0.1 |
| limonene | tr |
| 1,8-cineole | 1.1 |
| linalool | 0.6 |
| β-caryophyllene | tr |
| β-farnesene | 0.3 |
| α-terpineol | 0.1 |
| β-selinene | tr |
| α-selinene | tr |
| δ-cadinene | 0.1 |
| citronellol | 0.3 |
| an amyl benzoate | 0.2 |
| methyleugenol | 1.6 |
| nerolidol | 91.3 |
| E-methyl cinnamate | 3.6 |
| E,E-farnesol | 0.4 |

# *Melaleuca bracteata*

## River tea tree

*M. bracteata* is typically a large shrub or small bushy tree (5–10 m) but may reach 20 m in height. It has small prickly leaves and dark-grey hard bark. *M. bracteata* is one of the most widely distributed species of the genus in Australia, occurring in five States. It is frequently found growing along watercourses on rather heavy-textured deep clays. *M. bracteata* makes an excellent shelter tree with potential for small posts and poles.

*M. bracteata* has been shown to exist in four chemical forms. These are forms in which the aromatic ethers (I) elemicin, (II) E-isoelemicin, (III) E-methyl isoeugenol or (IV) methyl eugenol predominate in the oil. In all cases, no matter which component predominates (>40%), the other three were present in significantly lesser amounts.

In all chemotypes there were lesser amounts (up to a maximum of approximately 30%) of mono- and sesquiterpenes. Of these compounds, β-caryophyllene,

α-farnesene, α-phellandrene and α-pinene appear to be the major contributors. Also present in the oil were small, but significant, quantities of E-methyl cinnamate (0.1–9%) which no doubt gives the oil its sweet and fruity odour. The oil yield was generally low (0.1% on a dry weight basis) but one source from a species/provenance trial at Gympie (S14485, from north of Alice Springs) gave an oil yield of 1.3–2.4% on an air-dry leaf basis.

Oil yield (based on air-dry weight): 0.1–2.4%.

Oil use: *M. bracteata* has been mentioned as a potential source of the aromatic ethers methyleugenol, methyl isoeugenol and elemicin. Only a high-yielding source of oil has the potential for any exploitation.

Additional information on oils: Brophy et al. (1989).

### Chemotype I

| Compound | % |
|---|---|
| β-pinene | 0.1 |
| myrcene | 0.1 |
| α-phellandrene | 3.5 |
| α-terpinene | 0.1 |
| limonene | 0.3 |
| E-β-ocimene | 0.4 |
| terpinolene | 2.7 |
| mentha-1,3,8-triene | 0.8 |
| $C_{10}H_{16}O$ | 0.1 |
| α-copaene | 0.2 |
| β-caryophyllene | 21.4 |
| alloaromadendrene | 0.1 |
| methyl chavicol | tr |
| humulene | 1.9 |
| $C_{15}H_{24}$ | 0.2 |
| germacrene-D | 0.5 |
| $C_{15}H_{24}$ | 0.1 |
| bicyclogermacrene | 1.0 |
| δ-cadinene | 0.4 |
| cadina-1,4-diene | tr |
| anethole | tr |
| methyleugenol | tr |
| caryophyllene oxide | 0.2 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.4 |
| E-methyl cinnamate | 0.1 |
| palustrol | tr |
| E-methyl isoeugenol | 0.1 |
| unknown, mw240 | 0.2 |
| elemicin | 57.4 |
| $C_{15}H_{26}O$ | 0.5 |
| Z-isoelemicin | 0.1 |
| E-isoelemicin | 5.6 |

### Chemotype II

| Compound | % |
|---|---|
| α-pinene | 4.9 |
| β-pinene | 0.2 |
| myrcene | 0.4 |
| α-phellandrene | 12.7 |
| α-terpinene | 0.7 |
| limonene | 0.7 |
| 1,8-cineole | 0.4 |
| γ-terpinene | 0.1 |
| E-β-ocimene | 1.4 |
| terpinolene | 2.1 |
| mentha-1,3,8-triene | 3.2 |
| β-caryophyllene | 6.8 |
| alloaromadendrene | tr |
| methyl chavicol | tr |
| humulene | 0.5 |
| $C_{15}H_{24}$ | 0.1 |
| germacrene-D | 0.7 |
| $C_{15}H_{24}$ | 0.1 |
| bicyclogermacrene | 0.1 |
| α-farnesene | 2.8 |
| δ-cadinene | 0.4 |
| methyleugenol | 0.8 |
| caryophyllene oxide | 0.1 |

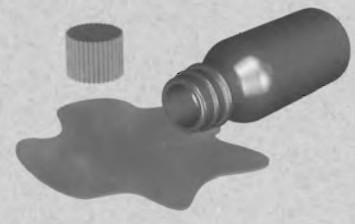
| | |
|---|---|
| E-methyl cinnamate | 1.4 |
| $C_{15}H_{26}O$ | 0.1 |
| palustrol | 0.1 |
| E-methyl isoeugenol | 0.9 |
| elemicin | 8.8 |
| $C_{15}H_{26}O$ | 1.5 |
| Z-isoelemicin | 0.1 |
| E-isoelemicin | 45.4 |

### *Chemotype III*

| Compound | % |
|---|---|
| α-pinene | 0.6 |
| β-pinene | tr |
| sabinene | tr |
| α-phellandrene | 0.1 |
| α-terpinene | tr |
| limonene | 1.4 |
| *p*-cymene | 0.1 |
| terpinolene | tr |
| benzaldehyde | tr |
| linalool | 0.3 |
| acetophenone | tr |
| methyl chavicol | 0.1 |
| acetotoluene | 0.2 |
| α-terpineol | 0.2 |
| methyleugenol | 17.5 |
| E-methyl cinnamate | 2.8 |
| E-methyl isoeugenol | 75.9 |
| elemicin | 0.1 |
| E-isoelemicin | 0.2 |

### *Chemotype IV*

| Compound | % |
|---|---|
| α-pinene | 0.6 |
| β-pinene | tr |
| sabinene | tr |
| myrcene | tr |
| α-phellandrene | 0.1 |
| α-terpinene | tr |
| limonene | tr |
| γ-terpinene | tr |
| *p*-cymene | 0.3 |
| terpinolene | tr |
| benzaldehyde | tr |
| linalool | tr |
| acetophenone | tr |
| methyl chavicol | tr |
| acetotoluene | 0.6 |
| α-terpineol | 0.3 |
| Z-anethole | tr |
| E-anethole | 0.1 |
| Z-methyl cinnamate | tr |
| methyleugenol | 45.7 |
| methyl methoxybenzoate | 0.1 |
| E-methyl cinnamate | 8.6 |
| E-methyl isoeugenol | 43.0 |
| elemicin | 0.2 |
| E-isoelemicin | tr |



# *Melaleuca cajuputi*

## Swamp tea tree

*M. cajuputi* is usually a tree up to 25 m tall with a single stem, although it may reach 40 m and 1.2 m in diameter in some situations. It displays dense erect dull-green foliage with grey to white papery bark. Figure 1.2 (p. 12) gives the approximate boundaries of the natural occurrence. The species grows in a wide range of situations but most stands are found on low swampy coastal plains often on heavy-textured black soils that are subject to flooding for six or more months each year. *M. cajuputi* is moderately fast-growing and is used for posts, poles, fuelwood, honey, ornament and shelter. It is also the source of Cajuput oil (see Introduction).

There are plans to recognise three subspecies within *M. cajuputi*: subsp. "*cajuputi*" from northwestern Australia and eastern Indonesia, subsp. "*cumingiana*" from Vietnam to western Indonesia and subsp. "*platyphylla*" from northern Queensland, southern Papua and adjacent islands.

### *Melaleuca cajuputi* subsp. "*cajuputi*"

The essential oil obtained from *M. cajuputi* subsp. "*cajuputi*" contained significant amounts of 1,8-cineole (15–60%) and the sesquiterpene alcohols globulol (0.2–8%), viridiflorol (0.2–10%) and spathulenol (0.4–30%) as the major components present. There were lesser amounts of limonene (1.3–5%), β-caryophyllene (1–4%), humulene (0.2–2%), viridiflorene (0.5–7%), α-terpineol (1–7%), α- and β-selinene (each 0.3–2%) and caryophyllene oxide (1–8%). The aromatic ether, cajeputol, was not detected in this subspecies. The oil yield, based on fresh leaves, was 0.4–1.2%.

### *Melaleuca cajuputi* subsp. "*cumingiana*"

The essential oil of *M. cajuputi* subsp. "*cumingiana*" was monoterpenoid in character. The main components detected in oil from Thailand and Vietnam were γ-terpinene (14–17%) and terpinolene (10–23%). These were accompanied by lesser amounts of the hydrocarbons α-pinene (2–8%), α-thujene (2–8%), α-phellandrene (0.2–2%), α-terpinene (1–3%), limonene (1–2%) and *p*-cymene (4–12%) as well as the ether 1,8-cineole (trace–7%). Oxygenated monoterpenes were represented by terpinen-4-ol (1–5%) and α-terpineol (1–3%).

The major sesquiterpenes detected in the oil were α-, β- and γ-eudesmol (0.5–2%), caryophyllene oxide (1–5%), α- and β-selinene (each 1–3%), viridiflorene (1–2%), humulene (3–14%), aromadendrene (1–5%) and β-caryophyllene (5–24%). There were only trace amounts of the aromatic ether, cajeputol. Oil yield, based on fresh leaves, was 0.3–0.5%.

Oil originating from Kalimantan in Indonesia was of the same overall pattern but contained much larger amounts of β-caryophyllene (23–44%) and humulene (9–14%). It also contained significant amounts of cajeputol (2–18%). The oil yield, based on fresh leaves, was 0.5–0.7%.

## *Melaleuca cajuputi* subsp. "*platyphylla*"

The essential oil obtained from *M. cajuputi* subsp. "*platyphylla*" was found to exist in two chemotypes.

Chemotype I occurred only near Wondo Village on the Bensbach River in Papua New Guinea. The chemotype contained, as the major component, the previously unknown β-triketone, platyphyllol (1-acetyl-4-methoxy-3,5,5-trimethylcyclohex-3-en-2,5-dione) (22–80%). This was accompanied by, among other compounds, cajeputol (1-acetyl-6-hydroxy-2,4-dimethoxy-3,5-dimethybenzene) (3–57%) and lesser amounts of terpenes, including spathulenol (4–10%), α-copaene (0.1–0.8%), β-caryophyllene (0.2–3%), alloaromadendrene (0.1–0.3%) and humulene (0.1–0.7%). The oil yield of this chemotype, based on fresh leaves, was 0.2–0.6%.

Chemotype II, from all other collection sites, contained significant quantities of α-pinene (12–70%), with lesser amounts of 1,8-cineole (0.1–10%), γ-terpinene (1–10%), *p*-cymene (0.1–7%), terpinolene (0.3–4%), β-caryophyllene (4–11%), aromadendrene (1–4%), humulene (3–8%), viridiflorene (0.2–2%), caryophyllene oxide (2–10%), globulol (2–7%), viridiflorol (0.6–2%) and spathulenol (1–3%). No trace of either cajeputol or platyphyllol was detected. The oil yield, based on fresh leaves, was 0.1–0.4%.

Oil yield (based on fresh weight): 0.1–1.2%.

Oil use: Subspecies "*cajuputi*" produces Cajuput oil in Indonesia. The use of platyphyllol and similar compounds as sunscreens, bactericides and fungicides has been patented (Joulain and Racine 1994).

Additional information on oils: Lowrey (1973), Brophy et al. (1988, 1989), Yaacob et al. (1989), Joulain and Racine (1994)

### *Melaleuca cajuputi* subsp. *"cajuputi"*

| Compound | % |
|---|---|
| α-pinene | 1.0 |
| α-thujene | 0.2 |
| β-pinene | 1.1 |
| sabinene | 0.1 |
| α-phellandrene | 0.5 |
| α-terpinene | 0.1 |
| limonene | 4.1 |
| 1,8-cineole | 48.8 |
| γ-terpinene | 0.2 |
| *p*-cymene | 0.6 |
| terpinolene | 0.1 |
| α-gurjunene | 0.1 |
| linalool | 0.1 |
| β-caryophyllene | 1.1 |
| aromadendrene | 0.9 |
| alloaromadendrene | 0.3 |
| humulene | 0.4 |
| β-farnesene | 0.1 |
| viridiflorene | 6.1 |
| α-terpineol | 5.5 |
| β-selinene | 0.9 |
| α-selinene | 0.8 |
| bicyclogermacrene | 0.6 |
| $C_{15}H_{24}O$ | 0.3 |
| palustrol | 0.1 |
| caryophyllene oxide | 1.1 |
| globulol | 2.1 |
| viridiflorol | 1.3 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.5 |
| spathulenol | 8.3 |

### *Melaleuca cajuputi* subsp. *"cumingiana" Indonesia*

| Compound | % |
|---|---|
| α-pinene | 10.3 |
| β-pinene | 0.5 |
| sabinene | 0.1 |
| α-phellandrene | 0.2 |
| limonene | 0.3 |
| 1,8-cineole | 1.7 |
| γ-terpinene | 0.1 |
| *p*-cymene | 0.0 |
| terpinolene | 0.1 |
| linalool | 0.2 |
| β-caryophyllene | 43.6 |
| aromadendrene | 1.0 |
| alloaromadendrene | 0.3 |
| humulene | 13.5 |
| viridiflorene | 0.6 |
| α-terpineol | 1.3 |
| β-selinene | 0.6 |
| α-selinene | 0.7 |
| bicyclogermacrene | 2.5 |
| δ-cadinene | 1.7 |
| palustrol | 0.1 |
| caryophyllene oxide | 0.8 |
| globulol | 1.5 |
| viridiflorol | 1.0 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| spathulenol | 0.7 |
| cajeputol | 17.5 |

### *Melaleuca cajuputi* subsp. *"cumingiana" Vietnam*

| Compound | % |
|---|---|
| α-pinene | 3.4 |
| α-thujene | 3.4 |
| β-pinene | 0.1 |

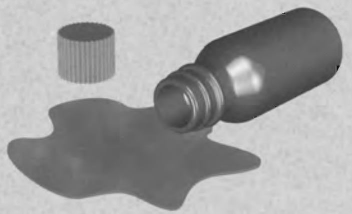
| | |
|---|---|
| sabinene | 0.0 |
| δ-3-carene | 0.2 |
| α-phellandrene | 1.1 |
| α-terpinene | 2.9 |
| limonene | 1.3 |
| 1,8-cineole | 0.0 |
| γ-terpinene | 19.4 |
| *p*-cymene | 7.0 |
| terpinolene | 19.6 |
| linalool | 0.1 |
| β-caryophyllene | 18.6 |
| aromadendrene | 0.6 |
| alloaromadendrene | 0.2 |
| humulene | 9.2 |
| viridiflorene | 0.8 |
| α-terpineol | 0.8 |
| β-selinene | 1.6 |
| α-selinene | 2.0 |
| palustrol | 0.2 |
| caryophyllene oxide | 0.9 |

### *Melaleuca cajuputi* subsp. *"platyphylla" Chemotype I*

| Compound | % |
|---|---|
| α-copaene | 0.5 |
| β–caryophyllene | 0.6 |
| alloaromadendrene | 0.1 |
| humulene | 0.6 |
| spathulenol | 9.0 |
| platyphyllol | 71.0 |
| cajeputol | 2.3 |

### *Melaleuca cajuputi* subsp. *"platyphylla" Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 67.9 |
| β-pinene | 1.3 |
| limonene | 1.1 |
| 1,8-cineole | 0.3 |
| γ-terpinene | 0.4 |
| *p*-cymene | 0.3 |
| terpinolene | 0.2 |
| β-caryophyllene | 1.9 |
| aromadendrene | 1.3 |
| alloaromadendrene | 0.3 |
| humulene | 0.9 |
| viridiflorene | 1.0 |
| α-terpineol | 1.1 |
| β-selinene | 1.0 |
| α-selinene | 0.6 |
| $C_{15}H_{24}O$ | 0.3 |
| palustrol | 0.1 |
| caryophyllene oxide | 1.5 |
| globulol | 3.3 |
| viridiflorol | 0.9 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.5 |
| $C_{15}H_{24}O$ | 1.2 |
| spathulenol | 2.1 |



# *Melaleuca cardiophylla*

## Umbrella bush

*M. cardiophylla* is a dense, prickly, spreading shrub 0.5–3 m tall and wide, with many interwoven, tangly branches. A native of Western Australia, it occurs in coastal heaths, in loamy or sandy soils associated with limestone. It also occurs on coastal islands. Umbrella bush is cultivated to a limited extent for ornamental purposes.

While overall a large number of both mono- and sesquiterpenes were detected, the oil of *M. cardiophylla* was sesquiterpenic in character. The major sesquiterpenes were the related alcohols globulol (8–9%), viridiflorol (4–6%), spathulenol (3–7%) and palustrol (0.5–1%). Also detected were the cadinol/ muurolol isomers each in amounts of 0.5–1% as well as a significant number of unidentified oxygenated sesquiterpenes in quantities of up to 1% (one compound 3–5%). Sesquiterpene hydrocarbons present in the oil included aromadendrene (0.5–1%), alloaromadendrene (1–2%), viridiflorene (2–4%),

germacrene-D (0.5–2%), bicyclogermacrene (1–3%) and δ-cadinene (1–2%). There was a lesser number of unidentified hydrocarbons present in amounts of less than 1%.

The usually encountered monoterpene hydrocarbons were found in this oil. The major contributors were α-pinene (3–9%), β-pinene (11–16%), myrcene (2–3%), α-phellandrene (1–2%), limonene (2–6%), Z-β-ocimene (1–3%), E-β-ocimene (1–3%) and *p*-cymene (2–3%). 1,8-cineole was present at only trace levels. Of the oxygenated monoterpenes present in the oil, the major members were linalool (0.2–0.4%), pinocarvone (0.2%), terpinen-4-ol (0.4–1%), *trans*-pinocarveol (0.2–0.5%) and α-terpineol (1–2%).

Oil yield (based on air-dry weight): 0.1–0.15%.

Oil use: Low yield and the nature of the oil make it of little commercial value.

| Compound | % |
|---|---|
| α-pinene | 8.5 |
| α-fenchene | 0.1 |
| camphene | 0.1 |
| β-pinene | 16.1 |
| sabinene | 0.1 |
| myrcene | 2.1 |
| α-phellandrene | 1.2 |
| α-terpinene | 0.1 |
| limonene | 4.2 |
| β-phellandrene | 1.8 |
| 1,8-cineole | 0.1 |
| Z-β-ocimene | 2.2 |
| γ-terpinene | 0.1 |
| E-β-ocimene | 2.3 |
| *p*-cymene | 2.1 |
| terpinolene | 0.5 |
| alloocimene | tr |
| α-*p*-dimethylstyrene | tr |
| α-cubebene | 0.1 |
| bicycloelemene | 0.1 |
| α-copaene | 0.3 |
| β-bourbonene | tr |
| $C_{10}H_{14}O_2$ | 0.2 |
| α-gurjunene | 0.3 |
| $C_{15}H_{24}$ | 0.1 |
| linalool | 0.2 |
| pinocarvone | 0.1 |
| β-ylangene | 0.1 |
| fenchol | 0.1 |
| β-copaene ..tent.. | 0.3 |
| β-caryophyllene | 0.1 |
| terpinen-4-ol | 0.9 |
| aromadendrene | 0.8 |
| α-bulnesene | 0.2 |
| $C_{15}H_{24}$ | 0.2 |
| $C_{15}H_{24}$ | 0.1 |
| alloaromadendrene | 1.5 |
| *trans*-pinocarveol | 0.3 |
| a muurolene | 0.9 |
| viridiflorene | 2.6 |
| α-terpineol | 1.2 |
| borneol | 0.1 |
| germacrene-D | 1.2 |
| $C_{15}H_{24}$ | 0.7 |
| bicyclogermacrene | 3.2 |
| δ-cadinene | 1.9 |
| cadina-1,4-diene | 0.1 |
| $C_{15}H_{22}O$ | 0.3 |
| calemenene | 0.1 |
| *p*-cymene-8-ol | tr |
| calacorene | 0.1 |
| $C_{15}H_{46}O$ | 0.1 |
| palustrol | 0.7 |
| $C_{15}H_{26}O$ | 0.8 |
| $C_{15}H_{26}O$ | 0.1 |

$C_{15}H_{26}O$ .............................. 0.2
$C_{15}H_{26}O$ .............................. 0.4
$C_{15}H_{26}O$ .............................. 0.4
$C_{15}H_{26}O$ .............................. 3.5
$C_{15}H_{26}O$ .............................. 0.2
globulol .............................. 8.3
viridiflorol .............................. 5.2
$C_{15}H_{26}O$ .............................. 0.1
$C_{15}H_{26}O$ .............................. 1.2
spathulenol .............................. 4.7
$C_{15}H_{24}O$ .............................. 0.3
$C_{15}H_{24}O$ .............................. 0.3
T-cadinol .............................. 0.5
T-muurolol .............................. 1.2
δ-cadinol .............................. 0.6
$C_{15}H_{24}O$ .............................. 0.3
$C_{10}H_{14}O$ .............................. 0.2
$C_{15}H_{24}O$ .............................. 1.2
α-cadinol .............................. 1.8

# *Melaleuca citrolens*

## Paperbark

*M. citrolens* is a small tree to 7 m in height or rarely a large shrub with furrowed, firm or slightly papery bark. It occurs in northern Australia usually in open forests, on sandy, stony or loamy soils. It has potential to produce posts and rails and the lemon-scented chemotype may have scope for development as a commercial essential oil.

*M. citrolens* has been shown to exist in three definite, possibly four, chemical forms. These chemotypes are characterised by the presence of (I) 1,8-cineole, (II) piperitenone, (III) citronellal and (IV) neral/geranial in significant amounts in the oils.

Chemotype I contained 1,8-cineole (34–50%) and terpinolene (10–20%) as major components in the oil. Other compounds present in significant quantities were α-pinene (2–5%), α-phellandrene (2–5%), limonene (2–4%), terpinen-4-ol (0.3–6%), β-caryophyllene (trace–5%), α-terpineol (1–7%) and globulol (1–5%). The oil yield of this chemotype was 1.5–2.4% on an air-dry weight basis.

Chemotype II gave an oil in which the major components were 1,8-cineole (8–32%), terpinolene (13–27%) and piperitenone (9–14%). These were accompanied by lesser amounts of α-thujene (4–7%), α-phellandrene (5–9%), γ-terpinene (2–11%), terpinen-4-ol (2–4%) and α-terpineol (2–5%). The oil yield of this chemotype was 2.9–6.1% on an air-dry weight basis.

Chemotype III contained neral (7–16%), geranial (9–26%), 1,8-cineole (12–28%) and terpinolene (0.1–7%) as major compounds. The oil yield in this case was 1.3–3.9% on an air-dry weight basis.

Chemotype IV contained 1,8-cineole (1–12%), citronellal (20–30%), isopulegol (4–13%), geranial (trace–22%), neral (0.9–14%) and geraniol (0.7–2%) as major compounds. The oil yield of this chemotype was 1.9–3.1% on an air-dry weight basis.

Oil yield (based on air-dry weight): 1.3–6.1%.

Oil use: The oil, particularly the lemon-scented chemotypes, may be of interest in perfumery/flavour applications.

Additional information on oils: Brophy and Clarkson (1989), Brophy et al. (1989), Southwell and Wilson (1993).

### *Chemotype I*

| Compound | % |
|---|---|
| α-pinene | 2.7 |
| β-pinene | 0.1 |
| sabinene | 0.1 |
| α-phellandrene | 3.5 |
| α-terpinene | 0.4 |
| limonene | 2.9 |
| 1,8-cineole | 39.9 |
| γ-terpinene | 3.1 |
| *p*-cymene | 1.4 |
| terpinolene | 12.1 |
| α-*p*-dimethylstyrene | 0.1 |
| bicycloelemene | 0.8 |
| *cis*-sabinene hydrate | 0.1 |
| linalool | tr |
| terpinen-4-ol | 6.1 |
| β-caryophyllene | 1.4 |
| aromadendrene | 1.0 |
| alloaromadendrene | 1.5 |
| $C_{10}H_{16}O$ | 0.4 |
| unknown | 2.0 |
| α-terpineol | 5.9 |
| viridiflorene | 2.6 |
| *p*-cymen-8-ol | 0.3 |
| palustrol | 0.2 |
| caryophyllene oxide | tr |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 1.0 |
| globulol | 4.6 |
| viridiflorol | 1.0 |
| $C_{15}H_{26}O$ | 0.5 |
| spathulenol | 1.4 |
| $C_{15}H_{24}O$ | 4.0 |

## Chemotype II

| Compound | % |
|---|---|
| α-pinene | 1.9 |
| α-thujene | 5.7 |
| β-pinene | 0.2 |
| sabinene | 0.6 |
| α-phellandrene | 9.7 |
| α-terpinene | 1.2 |
| limonene | 2.7 |
| 1,8-cineole | 26.9 |
| γ-terpinene | 7.3 |
| *p*-cymene | 4.6 |
| terpinolene | 15.2 |
| mentha-1,3,8-triene | 0.3 |
| mentha-1,4-8-triene | 0.4 |
| α-*p*-dimethylstyrene | 0.8 |
| *trans*-sabinene hydrate | tr |
| bicycloelemene | tr |
| *cis*-sabinene hydrate | 0.5 |
| linalool | tr |
| *cis*-menth-2-ene-1-ol | 0.1 |
| terpinen-4-ol | 2.5 |
| β-caryophyllene | tr |
| $C_{15}H_{24}$ | 0.1 |
| $C_{10}H_{16}O$ | 0.6 |
| α-terpineol | 4.9 |
| bicyclogermacrene | 0.2 |
| $C_{10}H_{16}O$ | 0.1 |
| *p*-cymen-8-ol | 2.1 |
| piperitenone | 12.6 |
| $C_{10}H_{16}O$ | 0.1 |
| globulol | 0.1 |
| unknown | 0.3 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.1 |

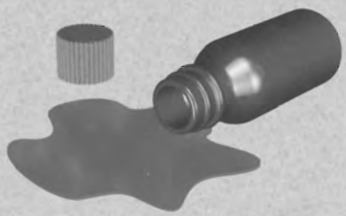
## Chemotype III

| Compound | % |
|---|---|
| α-pinene | 0.4 |
| α-thujene | 0.3 |
| β-pinene | 0.1 |
| sabinene | tr |
| myrcene | 1.5 |
| α-phellandrene | 0.1 |
| limonene | 1.9 |
| 1,8-cineole | 14.2 |
| γ-terpinene | 0.9 |
| *p*-cymene | 1.2 |
| terpinolene | 2.7 |
| α-*p*-dimethylstyrene | 0.1 |
| citronellal | 0.3 |
| isopulegol | 0.3 |
| terpinen-4-ol | tr |
| β-caryophyllene | 3.8 |
| aromadendrene | 0.1 |
| alloaromadendrene | 0.7 |
| citronellyl acetate | 2.3 |
| neral | 16.5 |
| α-terpineol | 3.1 |
| viridiflorene | 0.2 |
| geranial | 26.7 |
| bicyclogermacrene | 0.2 |
| citronellol | 0.3 |
| nerol | 0.1 |
| *p*-cymen-8-ol | 1.9 |
| $C_{15}H_{26}O$ | 0.5 |
| globulol | 2.0 |
| viridiflorol | 0.2 |
| spathulenol | 1.7 |
| $C_{15}H_{24}O$ | 0.1 |
| $C_{15}H_{24}O$ | 1.0 |

## Chemotype IV

| Compound | % |
|---|---|
| α-pinene | 0.5 |
| α-thujene | 0.4 |
| β-pinene | 0.1 |
| sabinene | tr |
| myrcene | 0.5 |
| α-phellandrene | 0.3 |
| α-terpinene | 0.1 |
| limonene | 1.4 |
| 1,8-cineole | 12.2 |
| γ-terpinene | 0.6 |

| | |
|---|---|
| *p*-cymene | 1.4 |
| terpinolene | 2.8 |
| α-*p*-dimethylstyrene | 0.2 |
| citronellal | 30.1 |
| bicycloelemene | tr |
| linalool | 0.2 |
| isopulegol | 5.4 |
| *iso*-isopulegol | 13.2 |
| terpinen-4-ol | 0.1 |
| β-caryophyllene | 3.8 |
| aromadendrene | 0.6 |
| alloaromadendrene | 0.2 |
| citronellyl acetate | 5.2 |
| humulene | 0.7 |
| neral | 0.9 |
| α-terpineol | 2.6 |
| citronellol | 3.4 |
| *p*-cymen-8-ol | 0.7 |
| geraniol | 0.7 |
| $C_{15}H_{26}O$ | 0.9 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| globulol | 0.3 |
| viridiflorol | 0.1 |
| spathulenol | 1.4 |



# *Melaleuca dealbata*

## Soapy tea tree

*M. dealbata* is a tree to 25 m with blue-grey foliage, densely haired branchlets and pale-brown papery bark. The species occurs along the coast of Queensland and is also found in southern Papua where it extends away from the lowlands to the dry woodlands of the Sogeri Plateau. *M. dealbata* is found on silty, sandy soils and clays, along the banks of streams, on seasonally swampy ground and on the edges of lagoons that may be brackish. It frequently occurs close to the sea and is a candidate for planting for soil reclamation, shelter belts and amenity purposes in coastal environments.

*M. dealbata* produced an essential oil in low yield. There was variation in oil components between predominantly monoterpene

and sesquiterpene types, but it is considered that there was just a wide range of oil types within this species rather than several chemotypes.

Oil obtained from a species/ provenance trial at Gympie (seed from Humpty Doo (S11935)) showed a predominance of sesquiterpenes, with spathulenol (11–19%), globulol (3–6%), viridiflorol (0.7–2%), the cadinols/ muurolols (each 1–3%), caryophyllene oxide (6–19%) and β-caryophyllene (13–33%) being the major contributors. Of the monoterpenes the only compounds of significance were E-β-ocimene (0.1–0.7%) and α-terpineol (0.5%). The oil yield from this species was 0.1% on a dry weight basis.

Trees from north of Mount Molloy (JD2070) contained many more monoterpenes, with α-pinene (10–36%), β-pinene (4–7%), limonene (5–7%), 1,8-cineole (2–12%) and *p*-cymene (2–9%) being among the largest contributors. The major sesquiterpenes were once again the alcohols globulol, viridiflorol and spathulenol (each 3–12%). The oil yield, on a fresh weight basis, from this source was 0.1–0.2%.

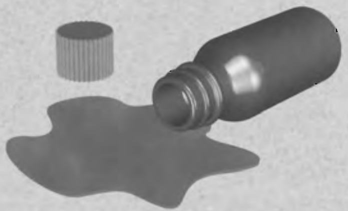
Oil yield (based on air-dry weight): 0.1–ca. 0.4%.

Oil use: Oil type and low yield rule out any commercial use.

Additional information on oils: Brophy et al. (1988, 1989).

| Compound | % |
|---|---|
| α-pinene | 0.8 |
| β-pinene | 0.3 |
| myrcene | tr |
| α-terpinene | tr |
| limonene | 0.8 |
| 1,8-cineole | tr |
| E-β-ocimene | 0.7 |
| *p*-cymene | tr |
| terpinolene | tr |
| a hexenyl ester | tr |
| rose oxide | tr |
| α-cubebene | tr |
| δ-elemene | tr |
| α-copaene | tr |
| benzaldehyde | 0.1 |
| α-gurjunene | 0.1 |
| longifolene | tr |
| terpinen-4-ol | 0.2 |
| β-caryophyllene | 23.8 |
| aromadendrene | 1.3 |
| α-bulnesene | 0.2 |
| alloaromadendrene | 0.8 |
| humulene | 1.3 |
| α-terpineol | 0.5 |
| viridiflorene | 0.9 |
| $C_{15}H_{24}$ | 0.2 |
| β-selinene | 0.8 |
| α-selinene | 1.0 |
| α-bisabolene | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| calamanene | 2.3 |
| calacorene | tr |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.2 |
| palustrol | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| caryophyllene oxide | 14.2 |

| | |
|---|---|
| $C_{15}H_{26}O$ | 0.7 |
| $C_{15}H_{26}O$ | 1.0 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 1.4 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 5.6 |
| viridiflorol | 1.2 |
| spathulenol | 11.6 |
| T-cadinol | 1.5 |
| T-muurolol | 2.5 |
| $C_{15}H_{26}O$ | 0.9 |
| $C_{15}H_{26}O$ | 2.2 |
| $C_{15}H_{24}O$ | 4.7 |
| $C_{15}H_{24}O$ | 3.7 |
| $C_{15}H_{26}O$ | 2.4 |
| $C_{15}H_{24}O$ | 1.3 |
| E,E-farnesol | 1.9 |



## *Melaleuca dissitiflora*

### Tea tree

*M. dissitiflora* is a tall bushy shrub to 5 m in height with erect or spreading branches and papery grey bark. It is found in sandy creek beds in the Flinders Ranges of South Australia as well as elsewhere in the north of that State and in the Northern Territory and western Queensland. It is a useful ornamental and low shelter-belt species for dry areas.

*M. dissitiflora* exists in two chemical forms. Chemotype I contains, as a major compound, 1,8-cineole (63–66%), with lesser amounts of limonene (5–7%), α-pinene (1–2%), terpinolene (3–4%), terpinen-4-ol (1–7%) and α-terpineol (4–9%). The oil yield of this chemotype was 1.9–2.2%, based on air-dry leaf. Chemotype II contains as a major compound terpinen-4-ol (38–52%). This was accompanied by lesser amounts of α-pinene (2–11%), β-pinene (0.5–15%), sabinene (1–15%), 1,8-cineole (1–8%), γ-terpinene (12–18%), terpinolene (2–4%) and α-terpineol (1–3%). The oil yield of this chemotype, based on air-dry leaf, was 1.4–4.2%. Neither chemotype contained sesquiterpenes in any significant amount.

Oil yield (based on air-dry weight): 1.4–4.2%.

Oil use: The terpinen-4-ol chemotype qualifies under the Australian Standard for use in "Australian Tea Tree Oil" manufacture.

Additional information on oils: Brophy and Lassak (1983), Brophy et al. (1989), Williams and Lusunzi (1994).

*Chemotype I*

| Compound | % |
|---|---|
| α-pinene | 1.7 |
| β-pinene | 0.8 |
| sabinene | 0.3 |
| myrcene | 1.0 |
| α-phellandrene | tr |
| α-terpinene | 0.7 |
| limonene | 6.1 |
| 1,8-cineole | 64.2 |
| γ-terpinene | 3.1 |
| *p*-cymene | 1.5 |
| terpinolene | 3.2 |
| α-*p*-dimethylstyrene | 0.2 |
| linalool | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| terpinen-4-ol | 3.3 |
| *trans*-β-terpineol | 0.1 |
| neryl acetate | 0.1 |
| $C_{10}H_{18}O$ | 1.5 |
| α-terpineol | 6.8 |
| α-terpinyl acetate | 0.1 |
| $C_{15}H_{24}$ | 0.5 |
| piperitone | 0.1 |
| geranyl acetate | tr |
| *trans*-piperitol | 0.5 |
| *p*-cymene-8-ol | 0.1 |

*Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 5.0 |
| camphene | tr |
| β-pinene | 8.0 |
| sabinene | 8.0 |
| myrcene | 1.0 |
| α-phellandrene | 0.5 |
| α-terpinene | 7.0 |
| limonene | 1.0 |
| 1,8-cineole | 5.0 |
| γ-terpinene | 15.0 |
| *p*-cymene | 8.0 |
| terpinolene | 3.0 |
| α-*p*-dimethylstyrene | 0.1 |
| linalool | 0.3 |
| $C_{15}H_{24}$ | 0.3 |
| $C_{15}H_{24}$ | 1.0 |
| terpinen-4-ol | 38.0 |
| aromadendrene | 0.5 |
| $C_{10}H_{18}O$ | 0.2 |
| α-terpineol | 2.0 |
| α-terpinyl acetate | tr |
| piperitone | 0.1 |
| geranyl acetate | 0.2 |
| *trans*-piperitol | 0.6 |

## *Melaleuca foliolosa*

*M. foliolosa* is a shrub or small tree up to 7 m in height with compact but papery bark and small (2–3 mm long, 1 mm wide) scale-like leaves. It is found in northern Queensland growing in shrubland, mostly on sandy soils but sometimes in areas with impeded drainage. It is a useful ornamental and screening plant.

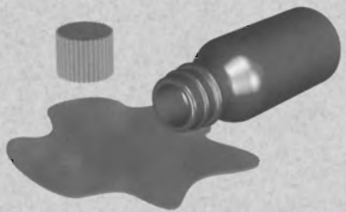
Two chemotypes (or at least a large variation) appeared to be present in the oils obtained from *M. foliolosa*. The first chemotype, from south of Emu Creek Lagoon, gave an oil that was monoterpenic in character with major amounts of terpinen-4-ol (23–30%) and α-terpineol (5–10%). Other significant monoterpenes detected in the oil were α-pinene (trace–8%), β-pinene (trace–4%), 1,8-cineole (1–7%) and *p*-cymene (1–17%). Other oxygenated monoterpenes present were *cis/trans*-menth-2-en-1-ols (each 0.1–0.5%), linalool (0.1–0.5%), geranial (0.1–2%) and geraniol (0.4–3%). The major sesquiterpenes present were caryophyllene oxide (0.5–6%), globulol (trace–1%), viridiflorol (trace–1%), spathulenol (1–13%), α-, β-, and γ-eudesmol (each 0.2–5%) and E,E-farnesol (1–3%). The oil yield was poor at 0.02–0.05%.

The second chemotype, from south of the Laura River crossing, contained significantly larger amounts of α-pinene (26–28%), 1,8-cineole (5–11%) and *p*-cymene (1–3%), and less of terpinen-4-ol (6–7%) and α-terpineol (3–5%). The quantities of sesquiterpenes detected in this chemotype were comparable with the other chemotype. The oil yield was, however, higher at 0.5–0.7%.

Oil yield (based on fresh weight): 0.02–0.7%.

Oil use: Low oil yield precludes any commercial use.

| **Compound** | % |
|---|---|
| α-pinene | 1.1 |
| α-fenchene | tr |
| camphene | tr |
| β-pinene | 1.0 |
| sabinene | 0.1 |
| myrcene | 0.6 |
| α-terpinene | 0.2 |
| limonene | 1.7 |
| β-elemene | tr |
| 1,8-cineole | 7.1 |
| Z-β-ocimene | tr |
| γ-terpinene | 0.6 |
| E-β-ocimene | 0.1 |
| *p*-cymene | 10.3 |
| terpinolene | 0.4 |
| a menthatriene | 0.1 |
| α-*p*-dimethylstyrene | 0.3 |
| linalool | 0.4 |
| *trans*-menth-2-en-1-ol | 0.2 |
| fenchone | 0.2 |
| terpinen-4-ol | 24.5 |
| β-caryophyllene | 0.4 |
| aromadendrene | 0.1 |
| *cis*-menth-2-en-1-ol | 0.1 |
| γ-elemene | 0.1 |
| *trans*-pinocarveol | 0.1 |
| humulene | 0.2 |
| $C_{15}H_{24}$ | 0.2 |
| a muurolene | 0.7 |
| α-terpineol | 9.6 |
| β-selinene | 0.8 |
| α-selinene | 0.5 |
| bicyclogermacrene | 0.2 |
| *trans*-piperitol | 0.1 |
| geranial | 1.3 |
| *trans*-mentha-1,8-dien-6-ol | 0.3 |
| geraniol | 0.9 |
| a calacorene | 0.1 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.2 |
| unknown, mw 164 | 0.6 |
| caryophyllene oxide | 4.1 |
| $C_{15}H_{24}O$ | 0.5 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.5 |
| globulol | 0.1 |
| viridiflorol | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| spathulenol | 2.6 |
| $C_{15}H_{26}O$ | 0.9 |
| γ-eudesmol | 2.4 |
| thymol | 0.6 |
| a cadinol | 1.8 |
| α-eudesmol | 2.4 |
| β-eudesmol | 3.5 |
| $C_{15}H_{24}O$ | 1.4 |
| $C_{15}H_{24}O$ | 1.9 |
| $C_{15}H_{24}O$ | 1.3 |
| $C_{15}H_{24}O$ | 1.6 |
| $C_{15}H_{24}O$ | 1.6 |
| E,E-farnesol | 1.2 |
| $C_{15}H_{24}O$ | 0.5 |
| $C_{15}H_{24}O$ | 0.3 |



# *Melaleuca lasiandra*

## Cadjibut

*M. lasiandra* is often a medium-sized, bushy shrub 2–3 m tall, but varies with site from a stunted shrub of 1 m to a small tree to 8 m, with papery bark. It occurs mainly in Western Australia and the Northern Territory, in coastal depressions, along drainage lines in desert areas and on rocky ridges on a wide range of soil types including sands, gravels and heavy clays. *M. lasiandra* has potential for soil protection and low shelter under severe climatic conditions.

The essential oil obtained from *M. lasiandra* was monoterpenic in character. The principal components were α-pinene (24–31%), β-pinene (8–11%), limonene (28–32%) and β-phellandrene (0.3–7%). These were accompanied by lesser amounts of terpinen-4-ol (0.1–2%), α-terpineol (2–4%), citronellol (0.2–0.5%), citronellyl acetate (0.2–0.5%) and the *p*-mentha-1(7),8-dien-2-ols and *p*-mentha-1,8-dien-6-ols (each 0.1–0.3%). Benzaldehyde (1–2%) was also detected.

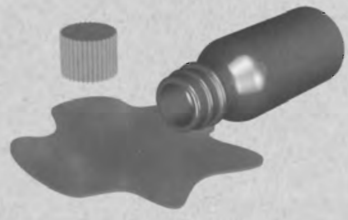
Sesquiterpenes did not contribute significantly to the oil. The principal compounds detected were β-caryophyllene (0.1–0.3%), caryophyllene oxide (1–2%), aromadendrene (0.2–1%), α- and β-selinenes (each 0.1–0.4%), globulol, viridiflorol and spathulenol (each 0.3–2%). The oil yield based on fresh leaves, was 0.2–0.3%.

Oil yield (based on fresh weight): 0.2–0.3%.

Oil use: Low oil yield mitigates against any commercial potential for this pleasant smelling oil.

Additional information on oils: Brophy et al. (1988, 1989).

| Compound | % |
|---|---|
| α-pinene | 22.8 |
| α-fenchene | tr |
| camphene | 0.2 |
| β-pinene | 11.1 |
| δ-3-carene | 0.4 |
| myrcene | 0.4 |
| limonene | 25.8 |
| 1,8-cineole | 4.1 |
| β-phellandrene | tr |
| E-β-ocimene | 0.1 |
| γ-terpinene | tr |
| *p*-cymene | 0.3 |
| terpinolene | 0.1 |
| α-*p*-dimethylstyrene | tr |
| *cis*-linalool oxide | tr |
| *trans*-linalool oxide | tr |
| α-campholinic aldehyde | tr |
| α-copaene | 0.1 |
| benzaldehyde | 2.1 |
| $C_{15}H_{24}$ | 0.2 |
| linalool | tr |
| terpinen-4-ol | 0.1 |
| β-caryophyllene | 1.4 |
| aromadendrene | 0.5 |
| α-bulnesene | 0.3 |
| alloaromadendrene | 0.3 |
| humulene | 0.3 |
| acetyltoluene ..tent.. | 1.9 |
| α-terpineol | 1.1 |
| viridiflorene | 0.4 |
| unknown | tr |
| $C_{15}H_{24}$ | 0.4 |
| $C_{15}H_{24}$ | 0.7 |
| β-bisaboline | 0.9 |
| δ-cadinene | 0.2 |
| *p*-cymene-8-ol | tr |
| geraniol | tr |
| palustrol | 0.1 |
| caryophyllene oxide | 0.6 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 4.0 |
| viridiflorol | 0.7 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| spathulenol | 0.1 |
| γ-eudesmol | 3.2 |
| $C_{15}H_{26}O$ | 1.2 |
| $C_{15}H_{26}O$ | 0.9 |
| α-eudesmol | 6.5 |
| β-eudesmol | 4.5 |
| $C_{15}H_{26}O$ | 0.1 |



# *Melaleuca leucadendra*

## Weeping paperbark

*M. leucadendra* is frequently a large tree 20–40 m tall with a diameter that may reach 1.5 m. Thin, shiny-green lanceolate leaves, attractive weeping habit and white papery bark are distinguishing features of this species. It is found mainly in coastal and subcoastal areas of tropical Queensland, the Northern Territory and Western Australia but extends inland for up to 350 km along major rivers. It is also found in Papua New Guinea, and in Irian Jaya and on various islands in eastern Indonesia. Soil types include silty to loamy clays or sandy loams over clay. *M. leucadendra* will tolerate waterlogging and is useful for posts, poles, fuelwood, shade, shelter and honey. The essential oils of some provenances may have commercial potential.

*M. leucadendra* has been shown to exist in two sets of chemical forms which are

geographically separated. One chemical form occurs from Western Australia across to approximately the middle of Northern Territory. This chemotype consists entirely of mono- and sesquiterpenes. The second set of chemotypes consists of either methyleugenol or E-methyl isoeugenol chemotypes. This second set of chemical forms occurs from mid Northern Territory eastwards to the Queensland coast.

Chemotype I, from Western Australia, had as its major compounds 1,8-cineole (10-45%), *p*-cymene (5–22%), α-pinene (4–19%), limonene (3–6%) and α-terpineol (0–9%). There was also a significant number of both mono- and sesquiterpenes present in small (<1%) quantities. The oil yield from this chemotype was 0.1–0.5% on a fresh weight basis.

Chemotype II, which extends into Queensland has two chemical forms. One form (IIb) contained methyleugenol (95–97%) as its principal component. The second chemical form (IIa) contained E-methyl isoeugenol (74–88%) as its major component with lesser amounts of methyl eugenol (6–24%) as a subsidiary component. The oil yield from this set of chemotypes was 1–4% on a fresh weight basis.

There appeared to be no interbreeding between chemotypes I and II; at one location in the Northern Territory both chemotypes occurred together but there was no sign of the aromatic compounds in the terpenic oil.

Oil yield (based on fresh weight): 0.1–4%.

Oil use: The eastern chemotype would be a useful source of methyleugenol if it were economic to recover it.

Additional information on oils: Brophy and Lassak (1988), Brophy et al. (1989).

### *Chemotype I Western Australia*

| Compound | % |
|---|---|
| α-pinene | 5.7 |
| α-fenchene | tr |
| camphene | tr |
| β-pinene | tr |
| δ-3-carene | 0.2 |
| myrcene | 0.4 |
| α-phellandrene | 0.5 |
| α-terpinene | 2.6 |
| limonene | 4.3 |
| 1,8-cineole | 31.0 |
| γ-terpinene | 17.4 |
| *p*-cymene | 4.7 |
| terpinolene | 9.6 |
| α-*p*-dimethylstyrene | 0.1 |
| $C_{15}H_{24}$ | tr |
| α-cubebene | 0.1 |
| campholenic aldehyde | 0.1 |
| linalool | 1.1 |
| isopulegol | 0.1 |

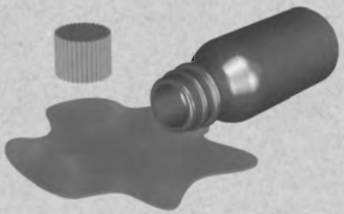
| | |
|---|---|
| *iso*-isopulegol | 0.5 |
| fenchone | 0.1 |
| terpinen-4-yl acetate | tr |
| terpinen-4-ol | 3.1 |
| β-caryophyllene | 0.3 |
| aromadendrene | 0.1 |
| α-bulnesene | tr |
| alloaromadendrene | 0.1 |
| $C_{15}H_{24}$ | tr |
| *trans*-pinocarveol | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| viridiflorene/α-terpineol | 9.1 |
| borneol | 0.4 |
| β-selinene | 0.1 |
| α-selinene | 0.1 |
| bicyclogermacrene | tr |
| citronellol | 0.6 |
| *trans*-mentha-1,8-dien-6-ol | tr |
| *p*-cymene-8-ol | 0.3 |
| $C_{15}H_{24}O$ | 0.1 |
| palustrol | tr |
| methyleugenol | 1.6 |
| $C_{15}H_{26}O$ | 0.2 |
| nerolidol | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| globulol | 0.3 |
| viridiflorol | 0.3 |
| $C_{15}H_{26}O$ | 0.3 |
| spathulenol | 0.1 |
| γ-eudesmol | 0.5 |
| α-eudesmol | 1.1 |
| β-eudesmol | 1.0 |
| E,E-farnesol | 0.4 |
| $C_{15}H_{26}O$ | 0.1 |

### Chemotype IIa eastern Australia

| Compound | % |
|---|---|
| E-β-ocimene | 0.3 |
| α-cubebene | tr |
| δ-elemene | tr |
| α-copaene | tr |
| α-gurjunene | tr |
| linalool | tr |
| acetophenone | tr |
| β-elemene | tr |
| β-caryophyllene | 0.4 |
| $C_{15}H_{24}$ | 0.4 |
| humulene | tr |
| germacrene-D | 0.3 |
| $C_{15}H_{24}$ | 0.1 |
| bicyclogermacrene | 0.1 |
| δ-cadinene | 0.2 |
| cadina-1,4-diene | 0.2 |
| calamene | 0.3 |
| methyleugenol | 6.7 |
| Z-methyl isoeugenol | 0.7 |
| E-methyl isoeugenol | 88.0 |
| $C_{15}H_{26}O$ | 0.5 |

### Chemotype IIb eastern Australia

| Compound | % |
|---|---|
| E-β-ocimene | tr |
| α-cubebene | tr |
| δ-elemene | tr |
| α-copaene | tr |
| α-gurjunene | tr |
| linalool | tr |
| acetophenone | tr |
| β-elemene | tr |
| β-caryophyllene | 0.4 |
| $C_{15}H_{24}$ | 0.4 |
| humulene | tr |
| germacrene-D | 1.2 |
| bicyclogermacrene | 0.3 |
| δ-cadinene | 0.4 |
| cadina-1,4-diene | 0.1 |
| calamene | 0.1 |
| methyleugenol | 94.6 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| Z-methyl isoeugenol | 0.2 |
| E-methyl isoeugenol | 0.4 |
| $C_{15}H_{26}O$ | 0.4 |



# *Melaleuca linariifolia*

## Narrow-leaved paperbark

*M. linariifolia* varies from a densely-branched shrub, 2–8 m in height, to an erect small tree of 10–15 m on favourable sites. The species occurs in eastern Australia, in New South Wales and southeastern Queensland, with a disjunct population on the Blackdown Tablelands in central Queensland.
*M. linariifolia* prefers well-watered areas and is most often found in open-forest on sandy soils along drainage lines and around swamps. It is an excellent shade and ornamental tree. Wood is durable for marine piles and makes an excellent firewood, and the leaves are rich in oils.

*Melaleuca linariifolia* can exist in two chemotypes, one of which is rich in 1,8-cineole while chemotype II is rich in terpinen-4-ol. Both chemotypes have few sesquiterpenes present in their oils.

The principal components found in the oil of chemotype I are 1,8-cineole (55.5%), α-pinene (5.9%), limonene (11.3%), α-phellandrene (2.3%) and α-terpineol (9.8%). The principal sesquiterpene found in this oil was globulol (1.6%).

Chemotype II produced an oil whose major compoments were terpinen-4-ol (36–48%), γ-terpinene (20.3%), α-terpinene (8.0%), limonene (2.0%), 1,8-cineole (3.0–8.3%), terpinolene (3.1%) and α-terpineol (5.2%). The principal sesquiterpene was globulol (1.0%). In both chemotypes, sesquiterpenes accounted for less than 10% of the oil.

Oil yield (based on fresh weight): 1.6–3.3%.

Oil use: The terpinen-4-ol rich oil of Chemotype II qualifies under the Australian Standard as a source of "Australian Tea Tree Oil".

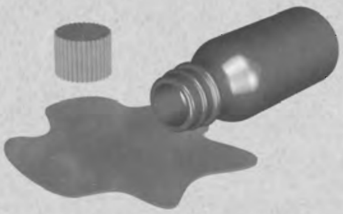
Additional information on oils: Brophy et al. (1989), Butcher et al. (1996), Southwell and Stiff (1990).

*Chemotype I*

| Compound | % |
|---|---|
| α-pinene | 5.9 |
| α-fenchene | tr |
| camphene | 0.1 |
| β-pinene | 1.3 |
| sabinene | tr |
| α-phellandrene | 2.3 |
| myrcene | 0.2 |
| α-terpinene | 0.2 |
| limonene | 11.3 |
| 1,8-cineole | 55.5 |
| γ-terpinene | 0.7 |
| E-β-ocimene | 0.2 |
| *p*-cymene | 0.3 |
| terpinolene | 0.3 |
| linalool | 0.1 |
| terpinen-4-ol | 0.9 |
| aromadendrene | 0.8 |
| alloaromadendrene | 0.4 |
| α-terpineol | 9.8 |
| δ-cadinene | 0.6 |
| globulol | 1.6 |
| viridiflorol | 0.7 |
| spathulenol | 0.3 |

*Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 3.4 |
| α-fenchene | tr |
| camphene | tr |
| β-pinene | 0.6 |
| sabinene | tr |
| α-phellandrene | 0.9 |
| myrcene | 0.4 |
| α-terpinene | 8.0 |
| limonene | 2.0 |
| β-phellandrene | 0.6 |
| 1,8-cineole | 8.2 |
| γ-terpinene | 20.3 |
| *p*-cymene | 3.5 |
| terpinolene | 3.1 |
| linalool | 0.1 |
| terpinen-4-ol | 35.8 |
| aromadendrene | 0.9 |
| alloaromadendrene | 0.3 |
| α-terpineol | 5.2 |
| δ-cadinene | 0.5 |
| globulol | 1.0 |
| viridiflorol | 0.5 |
| spathulenol | 0.3 |



# *Melaleuca linophylla*

## Paperbark

*M. linophylla* is a bushy shrub to 4 m in height with a papery bark. The narrow, flat leaves to 6 cm long are a distinguishing feature. This species occurs in creek beds and wet areas in the northwest of Western Australia. *M. linophylla* is not widely cultivated but has potential as an ornamental with showy flowers.

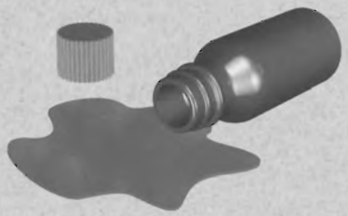
The leaf essential oil obtained from *M. linophylla* was heavily monoterpenic in character. By far the major component was 1,8-cineole (71–88%). It was accompanied by lesser amounts of limonene (4%), α-pinene (0.2–2%) and *p*-cymene (0.1–2%). With the exception of α-terpineol (0.2–12%), oxygenated monoterpenes were also present but only in very small amounts. The principal members being terpinen-4-ol (0.1–0.5%), δ-terpineol (0.2–0.3%) and the *p*-mentha-1(7),8-dien-2-ols and *p*-mentha-1,8-dien-6-ols (each 0.1–0.3%).

Sesquiterpenes were present in small amounts. The main contributors were the related tricyclic ringed compounds, globulol, viridiflorol and spathulenol (each 0.1–0.4%) and aromadendrene (0.1–0.2%).

Oil yield (based on fresh weight): 1–2%.

Oil use: This species could be a useful source of a cineole or "Cajuput" oil if it were economic to recover it.

| Compound | % |
|---|---|
| isovaleraldehyde | tr |
| α-pinene | 1.0 |
| α-fenchene | tr |
| camphene | 0.1 |
| β-pinene | 0.6 |
| sabinene | tr |
| myrcene | 0.9 |
| α-phellandrene | 0.1 |
| α-terpinene | 0.1 |
| limonene | 4.2 |
| 1,8-cineole | 75.6 |
| Z-β-ocimene | tr |
| γ-terpinene | 0.6 |
| E-β-ocimene | 0.2 |
| *p*-cymene | 0.3 |
| terpinolene | 0.2 |
| nonan-2-one | tr |
| α-*p*-dimethylstyrene | tr |
| α-cubebene | tr |
| α-gurjunene | 0.1 |
| linalool | 0.4 |
| isopulegol | tr |
| *iso*-isopulegol | tr |
| fenchol | tr |
| terpinen-4-ol | 0.7 |
| β-caryophyllene | tr |
| aromadendrene | 0.2 |
| α-bulnesene | tr |
| methyl benzoate | tr |
| alloaromadendrene | 0.1 |
| methylchavicol | tr |
| δ-terpineol | 0.2 |
| α-terpineol | 12.2 |
| geranial | tr |
| carvone | tr |
| δ-cadinene | tr |
| citronellol | 0.2 |
| calemenene | 0.1 |
| *trans*-mentha-1(7),8-dien-2-ol | 0.1 |
| *trans*-mentha-1,8-dien-6-ol | 0.1 |
| *p*-cymene-8-ol | tr |
| *cis*-mentha-1,8-dien-6-ol | tr |
| *cis*-mentha-1(7),8-dien-2-ol | 0.1 |
| palustrol | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| globulol | 0.5 |
| viridiflorol | 0.2 |
| $C_{15}H_{26}O$ | 0.3 |
| spathulenol | 0.2 |
| eugenol | 0.2 |
| $C_{15}H_{24}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.1 |



## *Melaleuca minutifolia*

*M. minutifolia* is a small tree or shrub, 4–8 m tall, with tiny stem-clasping leaves (hence the name), many branches and white papery bark.

*M. minutifolia* subsp. *minutifolia* occurs in northwestern Australia while *M. minutifolia* subsp. *monantha* is found in northern Queensland. Both subspecies, which differ mainly in their flowers and arrangement of oil glands, share a similar ecology, occurring in open forests or woodlands, usually in seepage areas and mostly on sandy soils. The species has potential as a screening plant in tropical areas.

The essential oil obtained from *M. minutifolia* subsp. *minutifolia* contained a mixture of both mono- and sesquiterpenes, with the latter predominating. The major monoterpenes detected in the leaf oil were the hydrocarbons α-pinene (16–19%), β-pinene (0.5–1%), limonene (0.1–0.4%) and the oxygenated compounds α-campholenic aldehyde (0.1–0.3%), *trans*-pinocarveol (0.5–1%), and geranyl acetate (0.4–1%).

A much larger number of sesquiterpenes occurred in this oil. The principal hydrocarbon components were β-caryophyllene (1–4%), aromadendrene (3–11%),

alloaromadendrene (2–3%), humulene (0.1–0.3%), viridiflorene (2–3%), β- and α-selinenes (each 0.3–0.6%) and bicyclogermacrene (7–10%). The major oxygenated components were globulol (7-8%), viridiflorol (2–4%), spathulenol (5–6%), γ-eudesmol (7–11%), α-eudesmol (5–7%), β-eudesmol (8–12%) and E,E-farnesol (0.3–1%). The oil yield, based on fresh leaves, was 0.4–0.6%.

The essential oil obtained from *M. minutifolia* subsp. *monantha* differed from the previous subspecies in that it contained a much greater proportion of monoterpenes. The major monoterpenes detected in the oil were the hydrocarbons α-pinene (20–54%) and β-pinene (14–30%). There were lesser quantities of myrcene (0.5–2%), limonene (3–4%), *p*-cymene (1–2%) and terpinolene (0.3–0.6%). Of the oxygenated monoterpenes terpinen-4-ol (1–2%), linalool (0.1%), borneol (0.7–2%), α-terpineol (4–7%) and *trans*-pinocarveol (1%) were the principal members.

Sesquiterpenes, while numerous, did not contribute largely to the oil. The major components were the hydrocarbons α-copaene (0.3–2%), β-caryophyllene (1–5%), aromadendrene (0.2–1%) and humulene (0.3–2%), and the alcohols spathulenol (1–5%), γ-eudesmol (0.5–2%), α-eudesmol (0.3–2%) and β-eudesmol (1–4%). There was also a significant number of oxygenated sesquiterpenes present at levels 0.2–1%. They have not yet been identified. The overall oil yield, based on dry weight of leaves, was 0.1–0.2%. This was less than the previous subspecies.

Oil yield (based on air-dry weight): 0.1–ca. 0.3%.

Oil use: There would be no commercial use for these oils.

## *Melaleuca minutifolia* subsp. *minutifolia*

| Compound | % |
|---|---|
| tricyclene | tr |
| α-pinene | 19.0 |
| α-fenchene | tr |
| camphene | 0.1 |
| β-pinene | 0.9 |
| sabinene | 0.3 |
| myrcene | 0.1 |
| α-terpinene | tr |
| limonene | 0.3 |
| 1,8-cineole | 0.1 |
| γ-terpinene | tr |
| E-β-ocimene | 0.1 |
| styrene | tr |
| *p*-cymene | 0.1 |
| terpinolene | tr |
| bornyl acetate ..tent.. | tr |
| α-*p*-dimethylstyrene | tr |
| α-cubebene | 0.1 |
| bicycloelemene | 0.1 |
| campholenic aldehyde | 0.2 |

| | |
|---|---|
| α-gurjunene | 0.2 |
| pinocarvone | 0.2 |
| unknown, mw168 | 0.1 |
| β-elemene | 0.2 |
| β-caryophyllene | 2.5 |
| aromadendrene | 9.4 |
| α-bulnesene | 0.6 |
| $C_{15}H_{24}$ | 0.2 |
| alloaromadendrene | 2.6 |
| *trans*-pinocarveol | 0.6 |
| humulene | 0.2 |
| $C_{15}H_{24}$ | 0.2 |
| viridiflorene | 2.4 |
| borneol | tr |
| verbenone | 0.1 |
| β-selinene | 0.5 |
| α-selinene | 0.3 |
| bicyclogermacrene | 7.2 |
| geranyl acetate | 0.7 |
| $C_{15}H_{22}$ | 0.1 |
| $C_{15}H_{20}$ | 0.4 |
| *trans*-mentha-1,8-dien-6-ol | 0.1 |
| *p*-cymene-8-ol | tr |
| geraniol | tr |
| $C_{15}H_{24}O$ | 0.4 |
| palustrol | 0.3 |
| caryophyllene oxide | 0.5 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.6 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.9 |
| globulol | 7.0 |
| viridiflorol | 2.5 |
| $C_{15}H_{26}O$ | 0.9 |
| $C_{15}H_{26}O$ | 0.9 |
| spathulenol | 5.4 |
| $C_{15}H_{24}O$ | 0.6 |
| γ-eudesmol | 7.7 |
| T-cadinol | 0.4 |
| unknown, mw 268 | 0.3 |
| $C_{15}H_{26}O$ | 0.3 |
| α-eudesmol | 5.7 |
| β-eudesmol | 9.1 |
| E,E-farnesol | 0.5 |

## *Melaleuca minutifolia* subsp. *monantha*

| Compound | % |
|---|---|
| tricyclene | tr |
| α-pinene | 20.0 |
| α-fenchene | 0.2 |
| camphene | 0.6 |
| β-pinene | 22.0 |
| sabinene | 0.2 |
| myrcene | 1.1 |
| α-phellandrene | 0.1 |
| α-terpinene | 0.2 |
| limonene | 3.5 |
| β-phellandrene | 0.3 |
| 1,8-cineole | 0.1 |
| γ-terpinene | 0.5 |
| E-β-ocimene | tr |
| *p*-cymene | 1.0 |
| terpinolene | 0.6 |
| *hex*-3-enyl acetate | 0.1 |
| bornyl acetate ..tent.. | tr |
| α-*p*-dimethylstyrene | 0.1 |
| campholenic aldehyde | 0.1 |
| α-copaene | 0.8 |
| linalool | 0.1 |
| pinocarvone | 0.1 |
| fenchol | 0.7 |
| unknown | 0.1 |
| terpinen-4-ol | 2.0 |
| β-caryophyllene | 4.2 |
| aromadendrene | 0.5 |
| α-bulnesene | tr |
| *trans*-pinocarveol | 1.0 |
| $C_{15}H_{24}O$ | 0.5 |
| methyl chavecol..tent.. | 0.3 |
| humulene | 0.9 |
| α-terpineol | 6.3 |
| borneol | 1.2 |
| $C_{15}H_{24}$ | 0.8 |
| $C_{15}H_{24}$ | 0.3 |
| $C_{15}H_{24}$ | 0.2 |
| $C_{15}H_{24}$ | 0.3 |
| α-muurolene | 1.0 |
| $C_{15}H_{24}$ | 0.4 |

| | |
|---|---|
| δ-cadinene | 1.4 |
| γ-cadinene | 1.2 |
| $C_{10}H_{16}O$ | 0.5 |
| $C_{15}H_{24}O$ | 0.44 |
| *trans*-mentha-1,8-dien-6-ol | 0.3 |
| calemenene + *p*-cymene-8-ol | 0.4 |
| a calacorene | 0.6 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| caryophyllene oxide | 0.1 |
| methyleugenol | 0.3 |
| $C_{15}H_{26}O$ | 1.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.5 |
| spathulenol | 4.2 |
| $C_{15}H_{24}O$ | 0.4 |
| γ-eudesmol | 1.9 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 1.1 |
| $C_{15}H_{26}O$ | 0.6 |
| α-eudesmol | 1.1 |
| β-eudesmol | 3.9 |
| $C_{15}H_{24}O$ | 0.3 |
| $C_{15}H_{24}O$ | 0.7 |
| $C_{15}H_{24}O$ | 0.7 |

# *Melaleuca nervosa*

## Yellow-barked paperbark

*M. nervosa* varies from a small shrub to a small tree (1–10 m). It is distributed across the tropical north of Australia and has a restricted occurrence in southwestern Papua New Guinea. *M. nervosa* grows on a wide range of sites and will tolerate infertile, periodically waterlogged and sometimes saline soils. It has potential for planting for fuel, small round timber and erosion control.

*M. nervosa* yielded an oil rich in sesquiterpenes, mostly oxygenated compounds, in low yield. The principal compounds determined in this oil were the hydrocarbons β-caryophyllene (6–18%), aromadendrene (0.2–3%), alloaromadendrene (0.2–4%), β-selinene (0.1%), α-selinene (trace–1%), calamenene (0.2–2%) and the oxygenated compounds caryophyllene oxide (7–9%), globulol (2–6%), viridiflorol (2–7%) and spathulenol (20–40%). There was a significant (>20) number of oxygenated sesquiterpenes whose identity has not been determined; these ranged in quantities from 0.1–7%.

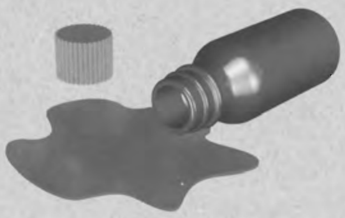
Monoterpenes were neither numerous nor abundant. The only compound of note was limonene (1–2%).

Oil yield (based on air-dry weight): 0.1–0.2%.

Oil use: There would be no commercial use for this oil.

Additional information on oils: Brophy et al. (1988, 1989).

| Compound | % |
|---|---|
| camphene | tr |
| β-pinene | tr |
| sabinene | tr |
| myrcene | tr |
| limonene | 2.0 |
| 1,8-cineole | tr |
| *p*-cymene | 0.1 |
| α-cubebene | tr |
| δ-elemene | tr |
| α-copaene | tr |
| β-bourbonene | 0.1 |
| linalool | 0.2 |
| terpinen-4-ol | tr |
| β-caryophyllene | 7.2 |
| aromadendrene | 0.2 |
| α-bulnesene | tr |
| alloaromadendrene | 0.2 |
| humulene | 0.3 |
| $C_{15}H_{24}$ | 0.2 |
| $C_{15}H_{24}$ | 0.1 |
| viridiflorene | 0.1 |
| $C_{15}H_{24}$ | 0.2 |
| β-selinene | 0.1 |
| α-selinene | 0.2 |
| α-muurolene | tr |
| δ-cadinene | 0.2 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{22}O$ | 0.6 |
| calamanene | 0.2 |
| calacorene | 0.3 |
| $C_{15}H_{26}O$ | 0.2 |
| palustrol | 0.7 |
| $C_{15}H_{26}O$ | 0.3 |
| caryophyllene oxide | 8.8 |
| $C_{15}H_{26}O$ | 1.9 |
| $C_{15}H_{26}O$ | 3.3 |
| $C_{15}H_{26}O$ | 1.5 |
| $C_{15}H_{26}O$ | 2.1 |
| $C_{15}H_{26}O$ | 3.3 |
| $C_{15}H_{26}O$ | 2.1 |
| globulol | 6.3 |
| viridiflorol | 6.4 |
| $C_{15}H_{26}O$ | 0.1 |
| spathulenol | 29.4 |
| $C_{15}H_{24}O$ | 3.6 |
| $C_{15}H_{24}O$ | 0.9 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 1.2 |
| $C_{15}H_{24}O$ | 0.5 |
| $C_{15}H_{24}O$ | 0.9 |
| $C_{15}H_{24}O$ | 0.3 |
| $C_{15}H_{24}O$ | 0.6 |
| $C_{15}H_{26}O$ | 0.7 |
| $C_{15}H_{26}O$ | 5.7 |
| $C_{15}H_{26}O$ | 0.6 |
| $C_{15}H_{26}O$ | 2.3 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 2.6 |



## *Melaleuca quinquenervia*

### Broad-leaved paperbark

*M. quinquenervia* is an erect, small to medium-sized tree, normally 8–12 m tall but sometimes reaching 25 m. It has stiff, leathery, lanceolate-elliptic leaves and white or greyish papery bark. The species is found along the east coast of Australia north from Sydney, in southern Papua New Guinea and in New Caledonia. *M. quinquenervia* occurs mainly along streams and in swamps on peaty humic gleys, but in New Caledonia it forms extensive stands in upland areas. The species produces an excellent firewood, provides useful timber and honey and is good for windbreaks and erosion control. Niaouli oil is produced from *M. quinquenervia* in New Caledonia.

*M. quinquenervia* is known to exist in two chemotypes. One chemotype contains large

amounts of E-nerolidol, while the second chemotype contains a large amount of 1,8-cineole. Within this second chemotype we have found trees in which the amount of 1,8-cineole is small and there is a large amount of the sesquiterpene alcohol, viridiflorol.

Chemotype I contained E-nerolidol (>95%) as its major component. This was accompanied by lesser quantities of E,E-farnesol, β-farnesene, β-caryophyllene, linalool, benzaldehyde and 1,8-cineole (all in trace–0.2%). The oil yield of this chemotype, based on fresh leaves, was 2%.

Chemotype II contained 1,8-cineole (50–65%) as its principal component. This was accompanied by lesser amounts of the hydrocarbons α-pinene (2–9%), myrcene (1–2%), limonene (6–8%), terpinolene (0.5–1%), β-caryophyllene (1–3%), aromadendrene (1–2%), α-terpineol (5–10%), viridiflorene (1–2%) and globulol (1–4%). There were a large number of both mono- and sesquiterpenes present in amounts of less than 1%. The oil yield of this chemotype was 1.3–2.4% based on fresh leaves.

As a variant on this chemotype, a group of trees produced an oil in which the major component was viridiflorol (80%). This was accompanied by lesser amounts of α-pinene (10%), limonene (2.5%), viridiflorene (1%), β-caryophyllene (0.4%) and benzaldehyde (0.2%). α-, β- and γ-eudesmol were also present (each <0.2%). The oil yield from this variant was 1.3%, based on fresh leaves.

Oil yield (based on fresh weight): 1.3–2.4%.

Oil use: Chemotype I is a good source of E-nerolidol, while Chemotype II is already used in New Caledonia for the production of "Niaouli" oil.

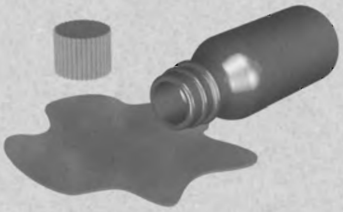
Additional information on oils: Brophy et al. (1989), Guenther (1950).

### *Chemotype I*

| Compound | % |
|---|---|
| 1,8-cineole | 0.2 |
| linalool | 0.1 |
| benzaldehyde | 0.1 |
| β-caryophyllene | 0.1 |
| β-farnesene | 0.1 |
| E-nerolidol | 95.0 |
| E,E-farnesol | 0.2 |

*Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 2.0 |
| camphene | tr |
| β-pinene | 0.8 |
| sabinene | 0.1 |
| myrcene | 1.2 |
| α-phellandrene | 0.1 |
| α-terpinene | 0.5 |
| limonene | 6.8 |
| 1,8-cineole | 64.9 |
| γ-terpinene | 0.7 |
| *p*-cymene | 0.4 |
| terpinolene | 0.5 |
| α-*p*-dimethylstyrene | tr |
| δ-elemene | 0.1 |
| linalool | tr |
| benzaldehyde | 0.1 |
| α-gurjunene | 0.1 |
| terpinen-4-ol | 0.2 |
| β-caryophyllene | 1.3 |
| aromadendrene | 1.7 |
| α-bulnesene | 0.1 |
| alloaromadendrene | 0.3 |
| δ-terpineol | 0.1 |
| humulene | 0.2 |
| α-terpineol | 9.9 |
| terpinyl acetate | tr |
| viridiflorene | 1.5 |
| β-farnesene | tr |
| bicyclogermacrene | 0.3 |
| $C_{10}H_{18}O$ | 0.4 |
| δ-cadinene | tr |
| γ-cadinene | tr |
| α-farnesene | 0.1 |
| calamanene | tr |
| palustrol | tr |
| nerolidol | tr |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| ledol | 0.2 |
| globulol | 3.4 |
| viridiflorol | 0.2 (80) |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.5 |
| spathulenol | 0.3 |
| $C_{15}H_{24}O$ | 0.1 |



# *Melaleuca saligna*

## Paperbark

*M. saligna* is a small to medium-sized tree 10–20 m tall with a pendulous crown and brownish papery bark. It has a limited distribution in far northern Queensland. *M. saligna* occurs on sandy or clay soils on flats and levees beside freshwater streams, surrounding depressions and swampy ground and behind mangroves close to the coast. The species has not been widely cultivated but it is likely that it would be suitable for timber, honey, shade and shelter in suitable environments in the lowland tropics.

The essential oil of *M. saligna* contained a spread of mono- and sesquiterpenes. The major monoterpenes detected were the hydrocarbons α-pinene (2–3%), β-pinene (1–2%), limonene (4–8%), γ-terpinene (0.2–4%) and terpinolene (0.2–1%) and the ether 1,8-cineole (8–30%).

The major sesquiterpenes, which made up the majority of the oil in most cases, were β-caryophyllene (5–7%), humulene (2–4%),

aromadendrene (0.3–1%), β-selinene (3–10%), α-selinene (3–8%), δ-cadinene (0.3–2%), caryophyllene oxide (1–4%) and the three eudesmols (0.5–3%). There were numerous unidentified sesquiterpenes, both hydrocarbons and oxygenated compounds, detected in the oil in quantities ranging up to 5%. Also detected in the oil was benzaldehyde (0.5–2%) and a compound whose mass spectrum indicated that it might be S-methyl benzothioate (0.2–0.5%).

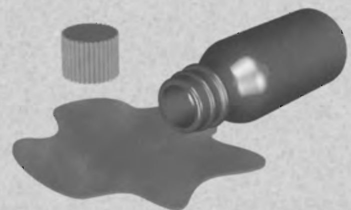
Also examined, were samples of this species originating from a species/provenance trial near Gympie, Queensland (S14149). The oil from this trial contained 1,8-cineole (66–70%) and α-pinene (2–9%) as its major components.

Oil yield (based on air-dry weight): 0.2–0.4%.

Oil use: No commercial use of this oil is foreseen.

| Compound | % |
|---|---|
| α-pinene | 3.1 |
| α-fenchene | tr |
| camphene | 0.1 |
| β-pinene | 0.8 |
| δ-3-carene | tr |
| myrcene | 0.7 |
| α-phellandrene | 0.1 |
| α-terpinene | 1.0 |
| limonene | 4.2 |
| β-phellandrene | tr |
| 1,8-cineole | 28.7 |
| Z-β-ocimene | tr |
| γ-terpinene | 3.4 |
| E-β-ocimene | tr |
| *p*-cymene | 0.6 |
| terpinolene | 0.6 |
| mentha-1,3,8-triene | tr |
| mentha-1,4,8-triene | tr |
| α-*p*-dimethylstyrene | tr |
| $C_{15}H_{24}$ | 0.2 |
| α-copaene | 0.1 |
| benzaldehyde | 0.5 |
| linalool | tr |
| $C_{15}H_{24}$ | tr |
| fenchone | tr |
| β-caryophyllene | 6.2 |
| terpinen-4-ol | 0.3 |
| aromadendrene | 0.4 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{24}$ | 0.9 |
| humulene | 2.4 |
| $C_{15}H_{24}$ | 0.1 |
| a muurolene | 0.8 |
| $C_{15}H_{24}$ | 2.1 |
| $C_{15}H_{24}$ | 0.3 |
| $C_{15}H_{24}$ | 0.3 |
| β-selinene | 3.3 |
| α-selinene | 3.4 |
| $C_{15}H_{24}$ | 0.2 |
| δ-cadinene | 0.3 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{24}$ | 0.2 |
| $C_{15}H_{24}$ | 1.5 |
| myrtenol | tr |
| calemenene | 0.2 |
| amyl benzoate | tr |
| calacorene | 0.3 |
| S-methyl benzothioate tent. | 0.3 |
| $C_{15}H_{26}O$ | 0.7 |
| caryophyllene oxide | 1.6 |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.6 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.6 |

| | |
|---|---|
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.7 |
| $C_{15}H_{26}O$ | 0.6 |
| $C_{15}H_{26}O$ | 5.2 |
| $C_{15}H_{26}O$ | 4.5 |
| $C_{15}H_{26}O$ | 1.6 |
| $C_{15}H_{26}O$ | 0.4 |
| γ-eudesmol | 0.2 |
| a cadinol | 1.4 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| α-eudesmol | 1.1 |
| β-eudesmol | 1.6 |
| $C_{15}H_{26}O$ | 3.8 |
| $C_{15}H_{22}O_2$ | 0.1 |
| $C_{15}H_{26}O$ | 1.3 |
| benzyl benzoate | 0.1 |



## Melaleuca sericea

### Paperbark

*M. sericea* is a tall shrub or small tree to 5 m in height with papery bark and hairy leaves, 15–50 mm long and 2–10 mm wide. It occurs on sandy loam on alluvial flats in low open woodland in northern Australia from the Kimberley area of Western Australia to the Victoria River area of the Northern Territory. *M. sericea* has not been widely cultivated and the range of potential uses for this species is unknown.

*M. sericea* produced an oil that was monoterpenic in character. There also appeared to be a variation in oil composition between the two locations from which samples of leaves were collected. In sample LAC9148 the major component was α-pinene (73–77%). This was accompanied by lesser amounts of isovaleraldehyde (0.3–7%), limonene (2%), 1,8-cineole (11–14%) and α-terpineol (2–4%). There was a significant number of sesquiterpenes present, both identified and unidentified, but all were in amounts of less than 1%. The oil yield from this source was 0.2–1.5%, based on fresh leaves.

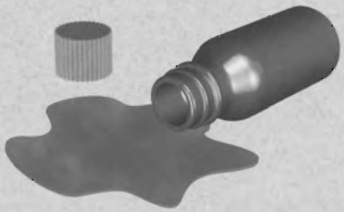
In sample LAC9149, the principal components were isovaleraldehyde (1–2%), limonene (6–12%), 1,8-cineole (26–36%) and α-terpineol (5–8%). The oil yield from this source was 0.5–1.3%, based on fresh leaves.

Oil yield (based on fresh weight): 0.2–1.5%.

Oil use: No commercial use for this oil is foreseen.

### *Melaleuca sericea* subsp. *sericea*

| Compound | % |
|---|---|
| isovaleraldehyde | 1.2 |
| unknown ketone, mw114 | 0.2 |
| α-pinene | 75.5 |
| α-fenchene | 0.1 |
| camphene | 0.3 |
| β-pinene | 0.2 |
| a methyl hexanoate | 0.1 |
| α-terpinene | tr |
| limonene | 2.1 |
| 1,8-cineole | 13.9 |
| Z-β-ocimene | 0.1 |
| γ-terpinene | 0.1 |
| E-β-ocimene | tr |
| *p*-cymene | 0.2 |
| terpinolene | 0.2 |
| $C_{10}H_{16}O$ | 0.2 |
| linalool | tr |
| pinocarvone | tr |
| $C_{10}H_{18}O$ | 0.2 |
| terpinen-4-yl acetate tent | tr |
| terpinen-4-ol | 0.1 |
| aromadendrene | 0.1 |
| α-bulnesene | tr |
| *trans*-pinocarveol | 0.4 |
| δ-terpineol | tr |
| α-terpineol | 3.3 |
| calemenene | tr |
| *cis*-mentha-1,8-dien-6-ol | 0.2 |
| *p*-cymene-8-ol | tr |
| *cis*-mentha-1,8-dien-6-ol | tr |
| palustrol | tr |
| unknown, mw164 | tr |
| caryophyllene oxide | tr |
| unknown, mw236 | tr |
| globulol | 0.1 |
| viridiflorol | tr |
| spathulenol | 0.1 |
| eugenol | 0.1 |



# *Melaleuca stenostachya*

## Paperbark

*M. stenostachya* is a shrub or tree, 4–25 m tall, with a small crown and stiff spreading branches. Bark may be hard or papery. Two varieties are recognised, namely the type and var. *pendula* which has pendulous branchlets. The species occurs in far northern Queensland and the northeastern Northern Territory and grows on a wide range of soils including sands, alluviums and skeletals that may be subject to inundation for short periods during the wet season. The wood is used in the round for posts and rails and has potential for fuel.

The essential oil obtained from *M. stenostachya* was monoterpenoid in character. The major components were the ether, 1,8-cineole (53–62%), and the hydrocarbons α-pinene (19–29%), β-pinene (1–2%), limonene (4–6%) and γ-terpinene (0.3–0.6%). Other monoterpenes detected were terpinen-4-ol (0.2–0.5%) and α-terpineol ( 1–3%).

The major sesquiterpenes detected were β-caryophyllene (2–6%), humulene (0.2–1%), caryophyllene oxide (0.4–1%),

globulol (0.4–1%), viridiflorol (0.1%) and spathulenol (0.1–1%). The oil yield, based on dry leaves, was 1.4–1.8%.

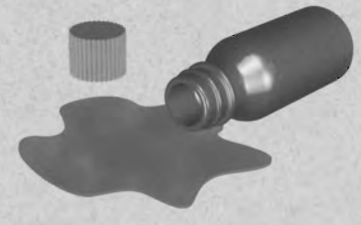
A second collection from north of the Laura River crossing, contained α-pinene (27–28%), β-pinene (41–44%) and 1,8-cineole (11–13%) as its major components. The oil yield from this source, based on fresh leaves, was 1–1.2%.

Oil yield (based on air-dry weight): 1.4–ca. 2.4%.

Oil use: No commercial use of this oil is foreseen.

Additional information on oils: Brophy et al. (1988, 1989)

| Compound | % |
|---|---|
| α-pinene | 28.9 |
| camphene | tr |
| β-pinene | 1.3 |
| sabinene | tr |
| myrcene | 0.4 |
| α-phellandrene | tr |
| α-terpinene | 0.1 |
| limonene | 4.2 |
| 1,8-cineole | 52.7 |
| γ-terpinene | 0.6 |
| *p*-cymene | 0.1 |
| terpinolene | 0.2 |
| rose oxide | tr |
| α-*p*-dimethylstyrene | tr |
| α-cubebene | tr |
| δ-elemene | tr |
| benzaldehyde | 0.1 |
| *trans*-menth-2-en-1-ol | tr |
| terpinen-4-ol | 0.2 |
| β-caryophyllene | 5.6 |
| aromadendrene | 0.1 |
| *cis*-menth-2-en-1-ol | tr |
| alloaromadendrene | 0.1 |
| δ-terpineol | tr |
| humulene | 0.7 |
| α-terpineol | 2.0 |
| viridiflorene | tr |
| bicyclogermacrene | tr |
| Z-α-bisabolene | tr |
| calamenene | tr |
| caryophyllene oxide | 0.4 |
| methyleugenol | 4.7 |
| $C_{15}H_{24}O$ | 0.1 |
| globulol | 0.6 |
| viridiflorol | 0.1 |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | 0.1 |
| spathulenol | 0.3 |
| $C_{15}H_{26}O$ | 0.5 |



# Melaleuca tamarascina

*M. tamarascina* ranges from a medium-sized shrub to small tree, 3 to 8 m tall, with small stem-clasping leaves. It occurs on sandy loams or poorly drained clay soils in central and southeastern Queensland and in northern New South Wales. Three subspecies are recognised, viz. the type and subsp. *pallescens* and subsp. *irbyana*. The latter, from northern New South Wales and the southeastern corner of Queensland (not included in the map), is not covered in this report. *M. tamarascina* is used as a useful screening and ornamental plant.

## *Melaleuca tamarascina* subsp. *tamarascina*

The leaf essential oil of *M. tamarascina* subsp. *tamarascina* contained α-pinene (85%) as its principal component. This was accompanied by lesser amounts of β-pinene (1–2%), limonene (3–5%), *p*-cymene (0.2–0.3%), linalool (0.4%), terpinen-4-ol (0.1–0.2%), *trans*-pinocarveol (1–2%) and α-terpineol (2.4%).

Sesquiterpenes were not major contributors to this oil. The principal compounds were globulol (0.2%), viridiflorol (0.1%), spathulenol (0.2%),

β-caryophyllene (0.1%) and aromadendrene (0.2%). The oil yield, based on fresh weight of leaves, was 0.2–0.3%.

### *Melaleuca tamarascina* subsp. *pallescens*

The leaf essential oil from this subspecies was monoterpenoid in character. The principal component was α-pinene (21–42%). This was accompanied by lesser amounts of β-pinene (0.2–0.7%), limonene (1%), *p*-cymene (0.2–0.4%), α-campholenic aldehyde (0.2–0.6%), pinocamphone, tentatively identified (7–14%), *trans*-pinocarveol (1–3%) and α-terpineol (3–5%). There were also several unidentified oxygenated monoterpenes in the range of 3–6%.

Sesquiterpenes, while numerous, did not make a major contribution to the oil. The principal components detected were globulol (2–5%), viridiflorol (1–2%), spathulenol (1%), palustrol (0.1–0.3%), aromadendrene (1–3%) and bicyclogermacrene (0.1–0.3%). There were also several suspected phenolic ethers accounting for 0.1–8% of the oil as well as unidentified oxygenated sesquiterpenes in the range of 0.2–2%. The oil yield, based on fresh leaves, was 0.2–0.4%.

Oil yield (based on fresh weight): 0.2–0.4%.

Oil use: No commercial use for this oil is foreseen.

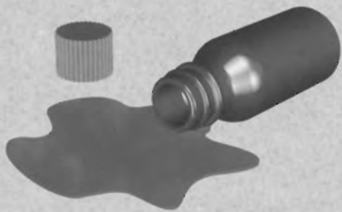
### *Melaleuca tamariscina* subsp. *tamariscina*

| Compound | % |
|---|---|
| α-pinene | 84.5 |
| β-pinene | 1.3 |
| limonene | 4.7 |
| γ-terpinene | 0.1 |
| *p*-cymene | 0.2 |
| terpinolene | 0.1 |
| linalool | 0.4 |
| pinocarvone | 0.1 |
| fenchol | 0.1 |
| terpinen-4-ol | 0.2 |
| β-caryophyllene | 0.1 |
| aromadendrene | 0.2 |
| *trans*-pinocarveol | 1.3 |
| α-terpineol | 2.4 |
| borneol | tr |
| myrtenol | 0.1 |
| *trans*-mentha-1(7),8-dien-2-ol | 0.1 |
| *trans*-mentha-1,8-dien-6-ol | 0.3 |
| *p*-cymene-8-ol | 0.1 |
| *cis*-mentha-1,8-dien-6-ol | tr |
| *cis*-mentha-1(7),8-dien-2-ol | tr |
| unknown, mw238 | tr |
| methyleugenol | 0.1 |
| unknown, mw236 | 2.0 |
| globulol | 0.2 |
| viridiflorol | 0.1 |
| spathulenol | 0.2 |
| unknown, mw250 | 1.5 |
| eugenol | 0.1 |

### *Melaleuca tamariscina* subsp. *pallescens*

| Compound | % |
|---|---|
| $C_9H_{14}$ | 0.3 |
| α-pinene | 41.3 |
| α-fenchene | 0.2 |

| | |
|---|---|
| camphene | 0.3 |
| β-pinene | 0.3 |
| $C_{10}H_{14}$ | 0.1 |
| myrcene | tr |
| α-terpinene | tr |
| limonene | 0.9 |
| β-phellandrene | tr |
| 1,8-cineole | tr |
| γ-terpinene | tr |
| *p*-cymene | 0.3 |
| terpinolene | 0.1 |
| isoamyl isovalerate | 0.1 |
| $C_{10}H_{16}O$ | 0.2 |
| $C_{10}H_{16}O$ | 0.2 |
| α-*p*-dimethylstyrene | 0.1 |
| a linalool oxide | tr |
| bicycloelemene | 0.1 |
| α-campholenic aldehyde | 0.3 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{10}H_{18}O$ | 3.8 |
| pinocarvone | 0.5 |
| pinocamphone | 7.2 |
| β-caryophyllene | 0.1 |
| terpinen-4-ol | 0.1 |
| aromadendrene | 1.2 |
| myrtenal | 0.8 |
| unknown $C_{10}$ cpd. | 0.1 |
| alloaromadendrene | 0.4 |
| *trans*-pinocarveol | 2.1 |
| unknown, mw224 | 0.2 |
| $C_{15}H_{24}$ | 0.2 |
| $C_{15}H_{24}$ | 0.3 |
| $C_{10}H_{16}O$ | 1.4 |
| α-terpineol | 4.2 |
| verbenone | 1.7 |
| a muurolene | 0.1 |
| bicyclogermacrene | 0.1 |
| $C_{10}H_{18}O$ | 1.4 |
| *trans*-mentha-1,8-dien-6-ol | 0.4 |
| *p*-cymene-8-ol | 0.5 |
| $C_{10}H_{18}O$ | 7.5 |
| unknown | 1.5 |
| palustrol | 0.1 |
| unknown, mw170 | 0.2 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| unknown, mw236 | 8.4 |
| $C_{15}H_{26}O$ | 0.5 |
| globulol | 2.3 |
| viridiflorol | 0.9 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.5 |
| spathulenol | 0.7 |
| unknown, mw250 | 0.1 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{26}O_2$ | 0.1 |



# *Melaleuca trichostachya*

## Paperbark

*M. trichostachya* ranges from a medium-sized shrub of a height of 2 m to a small tree of 15 m, with papery bark. It grows in sandy soils along creeks, rivers and gorges and has a wide distribution in Queensland, extending into northern New South Wales and with disjunct populations in South Australia and the Northern Territory.

*M. trichostachya* is closely related to and resembles *M. linariifolia*. It is an excellent shade and ornamental tree.

*M. trichostachya* occurs in at least two chemical forms. One form is high in terpinolene, while the other is rich in 1,8-cineole and contains significant amounts of terpinen-4-ol.

Chemotype I contained terpinolene (47–65%) as its major component. This is accompanied by lesser amounts of 1,8-cineole (9–24%), α-pinene (1–3%), limonene (2–4%), terpinen-4-ol (1–3%) and α-terpineol (1–4%). The oil yield of this chemotype, based on fresh leaves, was 1–1.5%.

Chemotype II contained 1,8-cineole (45–57%) and terpinen-4-ol (11–16%) as major components. These were accompanied by lesser amounts of α-pinene and α-thujene (each 1–2%), myrcene (1–2%), α-terpinene (1–4%), limonene (4–5%), γ-terpinene (8–12%), *p*-cymene (1–4%) and α-terpineol (0.2–7%). Sesquiterpenes, both in this chemotype and the previous chemotype, did not contribute significantly to the overall oil. The oil yield, based on fresh leaves, was 1.6–2.3%.

Oil yield (based on fresh weight): 1.0–2.3%.

Oil use: The high cineole content of Chemotype II rules it out as a source of "Australian Tea Tree Oil".

Additional information on oils: Brophy and Lassak (1983), Southwell et al. (1992).

### *Chemotype I*

| Compound | % |
|---|---|
| α-pinene | 3.1 |
| α-fenchene | tr |
| camphene | tr |
| β-pinene | 0.2 |
| sabinene | tr |
| myrcene | 1.2 |
| α-phellandrene | 3.8 |
| α-terpinene | 1.2 |
| limonene | 2.2 |
| 1,8-cineole | 11.3 |
| γ-terpinene | 3.6 |
| *p*-cymene | 0.5 |
| terpinolene | 65.0 |
| linalool | 1.1 |
| terpinen-4-ol | 1.2 |
| aromadendrene | 0.2 |
| α-bulnesene | tr |
| α-terpineol | 2.1 |
| *p*-cymene-8-ol | 0.3 |
| calacorene | 0.1 |
| globulol | 0.2 |
| viridiflorol | tr |
| spathulenol | 0.1 |

### *Chemotype II*

| Compound | % |
|---|---|
| α-pinene | 1.7 |
| α-thujene | 1.5 |
| α-fenchene | tr |
| camphene | tr |
| β-pinene | 0.5 |
| myrcene | 1.5 |
| α-terpinene | 1.9 |
| limonene | 5.1 |
| 1,8-cineole | 57.3 |
| γ-terpinene | 9.1 |
| *p*-cymene | 1.7 |
| terpinolene | 0.7 |
| linalool | tr |
| fenchol | tr |
| terpinen-4-ol | 11.7 |
| aromadendrene | 0.1 |
| α-bulnesene | tr |
| δ-terpineol | 0.2 |
| *cis*-piperitol | 0.1 |
| α-terpineol | 5.9 |
| bicyclogermacrene | 0.1 |
| *p*-cymene-8-ol | tr |
| calacorene | 0.4 |
| $C_{15}H_{26}O$ | tr |
| caryophyllene oxide | tr |
| globulol | 0.1 |
| viridiflorol | 0.1 |
| spathulenol | 0.1 |

# *Melaleuca viridiflora*

## Broad-leaved paperbark

*M. viridiflora* is typically a small tree, 5–10 m tall but may attain 25 m in height under favourable conditions. It has leathery, dull-green leaves and pale-brown papery bark. The species grows on a wide range of soils on swampy ground close to the coast or sometimes on drier inland sites. It is very common throughout much of northern Australia. It also occurs in southern Papua New Guinea and in Irian Jaya. *M. viridiflora* is useful for shelter and amenity planting and has potential to produce fuel, posts and poles.

There appear to be two chemotypes of *M. viridiflora*, Chemotype I being a terpenoid chemotype which showed a large amount of chemical variation, and Chemotype II in which the principal component was E-methyl cinnamate (Hellyer and Lassak 1968).

Chemotype I seemed to be highly variable. While all the collections of this chemotype were terpenoid in character, three different types of oil have been encountered. One oil, arising from trees grown at Gympie from seed collected northwest of Chillagoe (S14558) contained, as major components, γ-terpinene (39–47%) and terpinolene (26–33%). These were accompanied by lesser amounts of α-pinene (7–9%), α-phellandrene (0–4%), α-terpinene (7–9%), limonene (1–2%), terpinen-4-ol (0.7–2%) and β-caryophyllene (0.4–1%). The oil yield of this variant, based on dry leaves, was 1.3–2.1%.

A second chemical variant contained large amounts of 1,8-cineole (30–60%) as its major component. This was accompanied by significant amounts of the monoterpenes α-pinene (2–7%), β-pinene (1–5%), myrcene (tr–2%), limonene (5–10%), α-terpineol (5–8%) and the sesquiterpenes β-caryophyllene (0.5–10%), viridiflorene (tr–4%), globulol (1–8%), viridiflorol (0.3–9%) and spathulenol (3–14%). The oil yield of this variant was 0.4–0.7%, based on fresh leaves.

A third chemical variant contained lesser amounts of monoterpenes, particularly 1,8-cineole (6–12%) and much larger amounts of sesquiterpenes, β-caryophyllene (2–10%), spathulenol (4–15%) and globulol (2–13%). A large number of sesquiterpenes in amounts of less than 3% were present in this oil. The yield, based on air-dry leaves, was 0.4–0.9%.

Chemotype II consisted basically of two compounds, E-methyl cinnamate (81%) and E-β-ocimene (12%). The remainder of the oil was accounted for by 2,4,6-trimethoxyisobutyrophenone (5%), Z-methyl cinnamate (0.5%) and linalool (0.6%). The oil yield of this chemotype, based on air-dry leaves, was 4%.

Oil yield (based on air-dry weight): 0.4–4.0%.

Oil use: There is potential for Chemotype II as a source of methyl cinnamate, though the New England eucalypt, *Eucalyptus olida*, is a better prospect (Curtis et al. 1990).

Additional information on oils: Brophy et al. (1989), Lassak and Southwell (1977).

### *Chemotype I variety 1*

| Compound | % |
|---|---|
| α-pinene | 9.0 |
| β-pinene | 0.1 |
| myrcene | 0.5 |
| α-terpinene | 7.3 |

| | |
|---|---|
| limonene | 1.6 |
| 1,8-cineole | 0.3 |
| γ-terpinene | 39.0 |
| *p*-cymene | 2.9 |
| terpinolene | 32.6 |
| linalool | tr |
| terpinen-4-ol | 0.8 |
| β-caryophyllene | 0.7 |
| humulene | 0.2 |
| α-terpineol | tr |
| $C_{15}H_{24}O$ | 0.6 |

## Chemotype I variety 2

| Compound | % |
|---|---|
| α-pinene | 1.7 |
| camphene | tr |
| β-pinene | 0.8 |
| sabinene | tr |
| myrcene | tr |
| α-terpinene | tr |
| limonene | 4.6 |
| 1,8-cineole | 48.7 |
| γ-terpinene | 0.1 |
| *p*-cymene | 0.1 |
| terpinolene | 0.1 |
| δ-elemene | 0.1 |
| benzaldehyde | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| linalool | 0.4 |
| *trans*-menth-2-en-1-ol | tr |
| terpinen-4-ol | 0.2 |
| β-caryophyllene | 9.8 |
| aromadendrene | 1.2 |
| α-bulnesene | 0.5 |
| alloaromadendrene | 0.6 |
| *cis*-menth-2-en-1-ol | tr |
| humulene | 1.4 |
| δ-terpineol | 0.1 |
| β-farnesene | tr |
| α-terpineol | 6.2 |
| viridiflorene | tr |
| $C_{15}H_{24}$ | 2.1 |
| bicyclogermacrene | 2.6 |
| $C_{15}H_{24}$ | 0.1 |
| calamenene | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| calacorene | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| caryophyllene oxide | 3.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.7 |
| $C_{15}H_{24}O$ | 0.2 |
| globulol | 2.0 |
| viridiflorol | 0.3 |
| spathulenol | 3.7 |
| $C_{15}H_{24}O$ | 0.9 |
| $C_{15}H_{24}O$ | 0.5 |
| $C_{15}H_{26}O$ | 0.9 |
| $C_{15}H_{26}O$ | 0.3 |
| $C_{15}H_{26}O$ | 0.9 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{24}O$ | 1.2 |
| $C_{15}H_{24}O$ | 0.3 |
| $C_{15}H_{24}O$ | 0.3 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{24}O$ | 0.6 |

## Chemotype I variety 3

| Compound | % |
|---|---|
| α-pinene | 29.0 |
| camphene | tr |
| β-pinene | 0.8 |
| sabinene | tr |
| myrcene | tr |
| α-terpinene | tr |
| limonene | 1.3 |
| 1,8-cineole | 11.6 |
| γ-terpinene | 0.1 |
| *p*-cymene | 0.9 |
| terpinolene | tr |
| δ-elemene | tr |
| benzaldehyde | tr |
| linalool | 2.0 |
| *trans*-menth-2-en-1-ol | tr |
| terpinen-4-ol | 1.4 |
| β-caryophyllene | 2.1 |
| aromadendrene | 0.8 |
| α-bulnesene | 0.1 |

| | |
|---|---|
| alloaromadendrene | 0.5 |
| *cis*-menth-2-en-1-ol | tr |
| humulene | 0.5 |
| δ-terpineol | 0.1 |
| β-farnesene | tr |
| $C_{15}H_{24}$ | 0.1 |
| α-terpineol | 2.1 |
| viridiflorene | 0.1 |
| bicyclogermacrene | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| calamenene | 0.4 |
| calacorene | tr |
| $C_{15}H_{26}O$ | 0.2 |
| caryophyllene oxide | 1.7 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{24}O$ | 0.1 |
| globulol | 2.5 |
| viridiflorol | 0.3 |
| spathulenol | 15.5 |
| $C_{15}H_{24}O$ | 2.0 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 1.2 |
| $C_{15}H_{24}O$ | 2.0 |
| $C_{15}H_{24}O$ | 0.6 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{26}O$ | tr |
| $C_{15}H_{26}O$ | 6.7 |
| $C_{15}H_{26}O$ | 6.0 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.6 |
| $C_{15}H_{24}O$ | 0.8 |
| $C_{15}H_{24}O$ | 0.7 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.4 |
| $C_{15}H_{24}O$ | 0.1 |

### *Chemotype II*

| Compound | % |
|---|---|
| tricyclene | tr |
| myrcene | 0.1 |
| Z-β-ocimene | 0.2 |
| E-β-ocimene | 12.0 |
| benzaldehyde | tr |
| linalool | 0.6 |
| terpinen-4-ol | tr |
| β-caryophyllene | 0.1 |
| humulene | tr |
| α-terpineol | tr |
| Z-methyl cinnamate | 0.5 |
| E-methyl cinnamate | 81.2 |
| 2,4,6 trimethoxyisobuty-rophenone | 4.6 |
| unknown, mw 192 | 0.6 |

# *Melaleuca* sp. "Bukbuluk"

## Paperbark

This unnamed *Melaleuca* is soon to be formally recognised and is likely to be assigned the epithet "*stipitata*" (L. Craven, pers. comm.). It is a small tree to 6 m in height with a light branching, spreading crown and papery bark shedding in small strips. *M.* sp. "Bukbuluk" occurs in dense clumps on shallow loamy soils on shale rises. It is endemic to the Bukbuluk area of Kakadu National Park in the Northern Territory. The performance and range of potential uses of the species in cultivation are unknown.

The pleasant, lemon-scented oil obtained from *M.* sp. "Bukbuluk" was monoterpenic in character. The major components were neral (14%), geranial (30%) and terpinen-4-ol (10–11%). Other monoterpenes present in significant amounts were α-pinene (1%), β-pinene (0.5%), sabinene (6%), myrcene (2%), α-terpinene (4%), limonene (2%), 1,8-cineole (5%), γ-terpinene (6%), *p*-cymene (1%), terpinolene (1.2%), α-terpineol (5%), nerol (1%) and geraniol (1%).

The major sesquiterpenes were globulol (1%), viridiflorol (0.5%) and spathulenol (0.5%). The oil yield, based on fresh

leaves, from 17 trees averaged 1.6%, with a range of 0.7 to 3.1%. It would probably pay to investigate this species further with a view to sampling for greater terpinen-4-ol concentration while still retaining the lemon-scented components.

Oil yield (based on fresh weight): 0.7–3.1%.

Oil use: This species has potential as the source of a lemon-scented "Tea Tree Oil".

| Compound | % |
|---|---|
| α-pinene | 0.8 |
| α-thujene | 0.7 |
| β-pinene | 0.5 |
| sabinene | 6.0 |
| myrcene | 1.8 |
| α-phellandrene | 0.6 |
| α-terpinene | 3.6 |
| limonene | 2.1 |
| β-phellandrene | 1.0 |
| 1,8-cineole | 5.3 |
| γ-terpinene | 5.8 |
| E-β-ocimene | 0.4 |
| *p*-cymene | 1.1 |
| terpinolene | 1.2 |
| 6-methylhept-5-en-2-one | 0.1 |
| $C_{10}H_{14}O$ | tr |
| mentha-1,4,8-triene | tr |
| α-*p*-dimethylstyrene | 0.3 |
| *cis*-linalool oxide | tr |
| *trans*-linalool oxide | tr |
| α-cubebene | tr |
| bicycloelemene | 0.1 |
| *cis*-sabinene hydrate | 0.2 |
| *trans*-menth-2-en-ol | 0.1 |
| $C_{10}H_{16}O$ | 0.4 |
| terpinen-4-ol | 10.4 |
| aromadendrene | 0.2 |
| *cis*-menth-2-en-1-ol | 0.2 |
| neral | 13.7 |
| α-terpineol | 5.4 |
| geranial | 29.8 |
| bicyclogermacrene | 0.2 |
| δ-cadinene | 0.2 |
| nerol | 0.8 |
| geraniol | 0.8 |
| palustrol | 0.1 |
| methyleugenol | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 0.9 |
| viridiflorol | 0.5 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| spathulenol | 0.5 |
| $C_{15}H_{24}O$ | 0.3 |
| unknown, mw 208 | 0.2 |

## *Melaleuca* sp. "Cook District"

This unnamed *Melaleuca* is soon to be formally recognised and is likely to be assigned the epithet "*clarksonii*" (L. Craven, pers. comm.). It occurs as a shrub or small tree, 5–10 m tall, and may be multistemmed from ground level. The bark is variously described as hard and fissured or papery. It is common on cracking clay soils around seasonally waterlogged depressions and waterholes in far northern Queensland. The performance and range of potential uses of the species in cultivation are unknown.

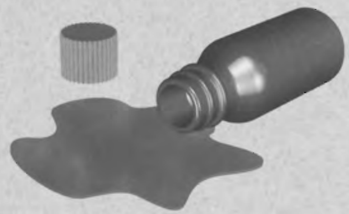
The essential oil of *M.* sp. "Cook District" was sesquiterpenic in character. The principal components of the oil were the related sesquiterpene alcohols globulol (17–22%), viridiflorol (10–13%), spathulenol (0.3–3%) and palustrol (1–2%). There were also significant amounts of, as yet, unidentified oxygenated sesquiterpenes. The major sesquiterpene hydrocarbons detected in the oil were β-caryophyllene (4–9%), aromadendrene (1–2%), alloaromadendrene (1–2%), humulene (0.5–1%) and bicyclogermacrene (2–6%).

Monoterpenes contributed little to the overall oil. The major components were the ether 1,8-cineole (4–11%), the hydrocarbons α-pinene (1–5%) and limonene (0.5%) and the alcohol α-terpineol (5–8%).

Oil yield (based on air-dry weight): 0.3–1.1%.

Oil use: No commercial use for this oil is foreseen.

| **Compound** | **%** |
|---|---|
| α-pinene | 3.7 |
| camphene | tr |
| β-pinene | 0.8 |
| sabinene | tr |
| myrcene | 0.2 |
| α-phellandrene | 0.1 |
| α-terpinene | 0.3 |
| limonene | 0.5 |
| β-phellandrene | 0.2 |
| 1,8-cineole | 10.2 |
| γ-terpinene | 0.6 |
| E-β-ocimene | 1.3 |
| *p*-cymene | 0.6 |
| terpinolene | 0.2 |
| α-cubebene | 0.1 |
| bicycloelemene | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| α-copaene | tr |
| α-gurjunene | 0.3 |
| $C_{15}H_{24}$ | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| β-elemene | 0.1 |
| terpinen-4-ol | 0.3 |
| β-caryophyllene | 7.3 |
| aromadendrene | 1.5 |
| α-bulnesene | 0.2 |
| alloaromadendrene | 1.2 |
| $C_{15}H_{24}$ | 0.1 |
| humulene | 0.6 |
| α-terpineol | 7.8 |
| viridiflorene | tr |
| β-selinene | 0.2 |
| α-selinene | 0.2 |
| bicyclogermacrene | 2.2 |
| δ-cadinene | tr |
| $C_{15}H_{24}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.2 |
| calacorene | tr |
| $C_{15}H_{24}O$ | 0.3 |
| palustrol | 1.3 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 1.6 |
| $C_{15}H_{26}O$ | 0.5 |
| $C_{15}H_{26}O$ | 1.1 |
| $C_{15}H_{26}O$ | 1.4 |
| elemol | 6.1 |
| globulol | 18.2 |
| viridiflorol | 10.9 |
| $C_{15}H_{26}O$ | 3.8 |
| $C_{15}H_{26}O$ | 7.1 |
| spathulenol | 0.3 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| methyleugenol | 0.2 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{26}O$ | 0.1 |
| $C_{15}H_{24}O$ | 0.2 |
| $C_{15}H_{26}O$ | 1.4 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{24}O$ | 0.7 |
| E,E-farnesol | 0.4 |
| baekeol | 1.6 |



## *Melaleuca* sp. "Laura"

This unnamed *Melaleuca* is soon to be formally separated from *M. argentea* and is likely to be assigned the epithet "*fluviatilis*" (L. Craven, pers. comm.). It is typically a small tree of about 4–20 m in height, with a deep crown, drooping branchlets and grey papery bark. It occurs on sandy-pebbly gravels of stream beds and banks in northeastern Queensland. The species has potential for posts, poles, fuelwood, honey, ornament and shelter.

The essential oil obtained from *M.* sp. "Laura" was monoterpenic in character. The major compounds detected were the ether 1,8-cineole (4–7%), and the hydrocarbons α-pinene (25–30%), β-pinene (9–12%), myrcene (0.5–1%), limonene (29–33%) and γ-terpinene (0.4–0.6%). Oxygenated monoterpenes detected in the oil included linalool (0.1%), fenchol (0.1%), terpinen-4-ol (0.5%), borneol (0.1–0.3%) and α-terpineol (1.5–3%).

While a significant number of sesquiterpenes was present they were all in small amounts. The principal compounds detected were the alcohols globulol (1–4%), viridiflorol (0.3–2%), spathulenol (1–2%)

and E,E-farnesol (0.3–0.4%), and the hydrocarbons β-caryophyllene (0.5–3%), aromadendrene (2–3%), alloaromadendrene (1–2%), humulene (0.3%), β-selinene (0.3%) and α-selinene (0.3–0.5%).

Oil yield (based on fresh weight): 0.1–0.3%.

Oil use: No commercial use for this oil is foreseen.

| Compound | % |
|---|---|
| α-pinene | 29.4 |
| α-fenchene | 0.2 |
| camphene | 0.6 |
| β-pinene | 11.3 |
| sabinene | tr |
| myrcene | 1.1 |
| α-phellandrene | 0.3 |
| α-terpinene | 0.1 |
| limonene | 32.4 |
| 1,8-cineole | 4.5 |
| Z-β-ocimene | tr |
| γ-terpinene | 0.5 |
| E-β-ocimene | tr |
| styrene | 0.1 |
| *p*-cymene | 0.6 |
| terpinolene | 0.4 |
| α-cubebene | 0.1 |
| α-copaene | 0.2 |
| α-gurjunene | 0.2 |
| linalool | 0.1 |
| $C_{15}H_{24}$ | 0.1 |
| fenchol | 0.1 |
| β-caryophyllene | 2.2 |
| terpinen-4-ol | 0.5 |
| aromadendrene | 2.2 |
| α-bulnesene | 0.3 |
| $C_{15}H_{24}$ | 0.5 |
| alloaromadendrene | 1.2 |
| $C_{15}H_{24}$ | 0.2 |
| humulene | 0.3 |
| neral | 0.1 |
| viridiflorene | 0.2 |
| α-terpineol | 1.8 |
| borneol | 0.3 |
| β-selinene | 0.2 |
| α-selinene | 0.3 |
| bicyclogermacrene | tr |
| δ-cadinene | 0.2 |
| γ-cadinene | 0.2 |
| citronellol | tr |
| cadina-1,4-diene | tr |
| $C_{15}H_{22}$ | 0.3 |
| calacorene | 0.1 |
| *cis*-mentha-1,8-dien-6-ol | tr |
| *p*-cymene-8-ol | tr |
| $C_{15}H_{24}O$ | 0.2 |
| palustrol | 0.1 |
| caryophyllene oxide | 0.4 |
| methyleugenol | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| $C_{15}H_{26}O$ | 0.2 |
| globulol | 1.5 |
| viridiflorol | 0.3 |
| $C_{15}H_{26}O$ | 0.4 |
| $C_{15}H_{26}O$ | 0.2 |
| spathulenol | 1.1 |
| eugenol | 0.1 |
| T-cadinol | tr |
| T-muurolol | tr |
| methyl isoeugenol | 0.1 |
| $C_{15}H_{24}O$ | 0.2 |
| E,E-farnesol | 0.3 |

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# Appendix 1

## Sample collection site details

*Asteromyrtus angustifolia*

Clarkson and Dunlop 9034, 0.5 km west of the beach on the track from the beach north of McIvor to Starke Station road, Qld, 15°07'S, 145°14'E.

*Asteromyrtus arnhemica*

Slee and Craven 3086, 2.9 km from turnoff to Jim Jim campground, Kakadu National Park, N.T., 13°15'S, 132°48'E.

*Asteromyrtus brassii*

Clarkson and Neldner 8892, 4.3 km southeast of Bromley on the track to Carron Valley, Qld, 12°28'S, 142°51'E.

*Asteromyrtus lysicephala*

Clarkson and Neldner 8871, 22 km east southeast of Bromley on the track to Carron Valley, Qld, 12°28'S, 142°59'E.

*Asteromyrtus magnifica*

Dunlop and Munns 8541, Kakadu National Park, N.T., 13°44'S, 132°37'E.

*Asteromyrtus symphyocarpa*

Slee, Craven and Brennan 2898, 2 km south along Snake Plain track from the road running west from Kakadu Highway towards Black Springs, N.T., 13°04'S, 132°10'E.

*Callistemon polandii*

Voucher. B. Hyland 6495 (QRS) (between McIvor River and Cape Flattery), cultivated at CSIRO, Atherton.

*Callistemon recurvus*

Voucher B. Hyland 8073 (QRS) (Carrington Falls), cultivated at CSIRO, Atherton.

*Callistemon salignus*

RG657, cultivated (book 1/16); RG654, cultivated (book 1/17); PF13854; BJL1242, 1.5 km NW of summit of Mt Beerwah, Qld.

*Callistemon viminalis*

Horse Gully, Woolooga to Biggenden Rd, 25°49'S, 152°17'E, PF13154, Mingo Crossing, Burnett River, 25°23'S, 151°46'E, PF13158; Wilgavale, near Texas, 28°55'S, 152°42'E, PF13284; Pasco River crossing, road to Iron Range, 12°53'S, 142°00'E, PF13530; Chester River, Silver Plains, PF13636; Spencer Creek, base of Windsor Tableland, 16°20'S, 145°05'E, PF13710; Pine Creek Crossing, 4 km SW of Marlborough, 22°44'S, 149°06'E, PF13776; Mt Dryander, Gregory Creek, 20°16'S, 149°50'E, PF13772; 1 km N of Colesseum Rail siding, near Miriamvale, 24°23'S, 151°36'E, PF13810; Paddy's Gully, Mt Maroon, 28°14'S, 152°42'E, PF14026; Dianas Bath, D'Aguilar Range, 27°06'S, 152°38'E, PF14029; Meteor Creek Crossing, Springsure to Rolleston road, 24°23'S, 148°27'E, PF14088; Starckvale Creek, Robinson Gorge, 25°18'S, 149°11'E, PF14102; Little Oakey Creek, Bonshaw to Strathbogie road, NSW, 29°14'S, 151°18'E, PF14256; Mulgrave River, 10.5 km along Doldborough road, 17°12'S, 145°45'E, PF14455; 6 km S of Tully Falls, 17°49'S, 145°33'E, PF14474; Herberton Weir, 17°22'S, 145°25'E, PF14480; PF14596, Teddington Weir, 25°39'S, 152°39'E; Koolkoorum Creek, 24°26'S, 151°11'E, PF14514; JB732, Cultivated at Randwick; JB731, Cultivated at Randwick; RG648, cultivated (book 1/20); RG656, cultivated (book 1/22); Rainbow Falls, Blackdown Tableland, 23°51'S, 149°05'E, PF13786.

### *Melaleuca acacioides* subsp. *acacioides*

S14146, SE Weipa (Gympie trials); RJG677,678, Cape York; BVG2695(S18964), Bandaler village, Western Province, PNG, 8°59'S, 141°19'E.

### *Melaleuca acacioides* subsp. *alsophila*

Derby region, 50 km S.E.. W.A.; Broome, W.A., collected J. Martin; Wyndham, GJM1764 ; DL828 (S18908), Cambridge Gulf, W.A., 14°55'S, 128°34'E.

### *Melaleuca arcana*

S14866, NNE Tozers Gap (Gympie trial); S14876, NW Cooktown (Gympie trial) 5.3 km N of Wakorka on the track to Cape Melville. 14°26'S 144°31'E, alt. 40m, JRC9761 &#VJN ; Hopevale, Qld (JD).

### *Melaleuca argentea*

N.T. 21°03', 140°57', BVG 2251,2, 3-5 (Brian Gunn); Finnis River, on the Wangi Rd towards Litchfield, N.T., BVG 2307-2309; GJM1767 (or 9) (Jock Morse); Fitzroy River, GJM1797; Dunham River, W.A. MM1640-1642; DL870(S18917), W Alligator River, Kapalga, N.T., 12°39'S, 132°17'E; DL842 (S18913), Kalumburu Mission, W.A., 14°18'S, 126°38'E; DL865 (S18916), Timber Creek, Victoria River, N.T., 15°39'S, 130°28'E; DL812(S18905), Keep River, N.T., 15°24'S, 129°11'E; DL779 (S18897), Finniss River, N.T., 13°04'S, 130°58'E.

### *Melaleuca cajuputi* subsp. *"cajuputi"*

DL890 (S18921), Flying Fox Creek, Kapalga, N.T., 12°40'S, 132°19'E; DL785 (S18898), Wongi, W of Litchfield NP, N.T., 13°09'S; 130°35'E; DL779 (S18897), Mataranka, Roper River, N.T., 14°56'S, 133°08'E.

### *Melaleuca cajuputi* subsp. *"cumingiana"*

Thailand, Toh Daeng Peat Swamp Forest, Narathivas Pr.; Vietnam, tree MV2; Vietnam, small shrub MV3; Nhon Hung, An Giang Pr, Vietnam; Phu Quoc Island, Kien Giang Pr, Vietnam; Tan Thanh, Long An Pr, Vietnam; Trem River, Hinh Hai Pr, Vietnam; Upper U Minh, Kien Giang Pr, Vietnam; Vinh; Hung, Long An Pr, Vietnam; Vo Doi Forest Conservation Area, Minh Hai Pr, Vietnam.

### *Melaleuca cajuputi* subsp. *"platyphylla"*

DL721 (S18958), Bensbach River, Wondo village, Western Province, PNG, 8°53'S, 141°17'E; DL745

(S18961), Kuru village, Western Province, PNG, 8°52'S, 143°05'E.

### *Melaleuca citrolens*

JRC7362, 0.5 km N Koolburra Creek on Peninsular Development Rd; JRC7363, 5.5 km S Laura River Crossing on Peninsular Development Road; JRC7734-7743, 0.5 km N Koolburra Creak on Peninsular Development Road.; JRC7724-7733, 2.3 km S Morehead River on Peninsular Development Road; JRC7717-7721, 0.9 km N Big Coleman River on Peninsular Development Road; 10.4 km north west of Koolatah on the track to Emu Lagoon, 15°33'S, 142°24'E, JRC9594.

### *Melaleuca dealbata*

S11935, Humpty Doo, N.T. (Gympie trial); a few km N of Mt Molloy, ND Rd, N. Qld, JD2070-2072; BVG2342,3,5; BVG2344 (flush growth); AG1 (S18923), Marrakai Conservation Reserve, N.T., 12°40'S, 132°19'E; DL897 (S18922), Flying Fox Creek, Kapalga, N.T., 12°40'S, 132°19'E; DL823 (S18907), Cambridge Gulf, W.A., 14°55'S, 128°34'E; DL774 (S18896), Mataranka, Roper River, N.T., 14°56'S, 133°08'E; DL747, Kuru village, Western Province, PNG, 8°52'S, 143°05'E.

### *Melaleuca dissitiflora*

BJL1404; BVG2509-2511; LAC9116; LAC9129; Charles River, N.T.; Davenport Ranges, N.T.; Alice Springs, N.T. (JD).

### *Melaleuca foliolosa*

2.3 km south of Emu Lagoon on the track from Kowanyama to Koolatah via Shelfa crossing, 15°28'S, 142°10'E, JRC9581; 11.9 km south of Laura River crossing, ND Rd, 15°38'S, 144°30'E, JD2056-2058.

### *Melaleuca lasiandra*

S13751, Vaughan Springs (Gympie trial); S13752, Rabbit Flat (Gympie trial); BVG2452-4; BVG2453; LAC9292, Shay Gap, road junction with Port Headland-Broome road, 19°58'S, 120°12'E.

### *Melaleuca leucadendra*

S13532, Iron Range, (Gympie trial); S13567, Mareeba (Gympie trial); S14147, Weipa (Gympie trial); S13567, Mareeba (Gympie trial); Gibb River, W.A.; Red Rock Creek, W.A.. GJM1750 (Jock Morse); Fitzroy River, GJM1798; DL885 (18920), Flying Fox Creek, Kapalga, N.T., 12°40'S, 132°19'E; BVG2660(S18956), Bensbach River, Wondo village, Western Province, PNG, 8°53'S, 141°17'E; DL817 (18906), Keep River, N.T., 15°24'S, 129°11'E; DL847 (18914), Kalumburu Mission, W.A., 14°18'S, 126°38'E; DL829 (18909), Cambridge Gulf, W.A., 14°55'S, 128°34'E; DL795 (18900), Wongi, W of Litchfield N.P., 13°09'S, 130°35'E; DL784, Mataranka, Upper Roper River, N.T., 14°56'S, 133°08'E; DL746 (18960), Kuru village, Western Province, PNG, 8°52'S, 143°05'E.

### *Melaleuca linariifolia*

JB1671 from BJL884 (no collection details); JB185, Gympie (S14979), 1 km S of The Lynd 18°56'S, 144°30'E; JD36-41, Bot. Specs RH1-RH4 (Toolara, Qld), MP1 (Tuan, Qld, SF915, Dinna LA Cpt 17), MP2 (Toolara Qld, SF1004, S. Dempster LA, Cpts 202 & 32); JD26, S of Tiaro, about 60 km N of Gympie.

### *Melaleuca linophylla*

LAC9306, Hamersley Iron rail maintenance road near Western Creek crossing, 21°12S, 117°01'E; Parabadoo, W.A. (GJM); Yule River, W.A. (GJM).

### *Melaleuca minutifolia* subsp. *minutifolia*

Dunham River, W.A., MM1643-1645; LAC9145, 20 km E of Victoria River crossing along Victoria Highway, 15°35'S, 131°15'E.

### *Melaleuca minutifolia* subsp. *monantha*

0.6 km from Mt Molloy along Wetherby Rd, N. Qld. JD2075; 3 km N of the Kennedy Highway on Emerald End Rd 16°59'S, 145°26'E JRC 9115A.

### *Melaleuca nervosa*

S13440, Lake Buchanan (Gympie trial); S13440, Lake Buchanan (Gympie trial); M. Bestman's property, La Spina Rd, Mareeba, 17°01'S, 145°24'E, JRC9391; BVG2347-9; BVG2442; BVG2443-4; BJL1195, 500 m SW of Capricorn Highway on road to Blackdown Tableland, 23°37'S, 149°12'E.

### *Melaleuca quinquenervia*

Euluma Creek Rd, near Julatten, Qld. 16°36'S, 145°21'E, JD2006-8; N of Kuranda Qld (JD); S14902, MW Mt Molloy (Gympie trial); UNSW Upper Campus, JJB; EVL—New Caledonia—bulk sample; EVL—New Caledonia—single tree; UNSW Lower Campus, JJB; DL734, Bimadebun, Western Province, PNG.

### *Melaleuca saligna*

1.5 km from Starcke landing on the track to Cape Melville, 14°26'S, 145°00'E, alt 5m, JRC9748 & VJN; 4km north of Kennedy R, ND Rd, N.Qld, 15°25'S, 144°09'E, JD2044-2046.

### *Melaleuca sericea*

LAC9148-9, 13 km W of Timber Creek along Kununurra road, 15°37'S, 130°22'E; DL810(S18904), East Baines River, N.T., 15°43'S; 130°06'E.

### *Melaleuca stenostachya*

S14149, Weipa (Gympie trial); 3 km N of Little Laura River crossing, ND Rd, 15°32'S, 144°22'E, JD2036-2038.

### *Melaleuca tamariscina* subsp. *tamariscina*

BJL1190, 37.7 km S of Blackwater on road to Rolleston, Qld.

### *Melaleuca tamariscina* subsp. *pallescens*

BJL1307, 3.3 km S of Miles on road to Condamine, 26°41'S, 150°11'E; BJL1319, 8.5 km WSW of Leichhardt Development Road on Bullock Head road, about 40.5 km SW of Tara, 27°30'S, 150°08'E; BJL1345, 4 km SSE of Inglewood on road to Texas, 28°27'S, 151°05'E.

### *Melaleuca trichostachya*

16 km north of Maytown on the Maytown track JRC 9623; BVG2526-28, Flinders River, Hughendon; Hugh River, N.T., EVL.

### *Melaleuca viridiflora*

S11935, Iron Range (Gympie trial); S14589, NNW Rockhampton (Gympie trial); S14558, NW Chillagoe (Gympie trial); 1 km N of the Iron Range turnoff on the Peninsula Development Rd, 13°20'S, 142°52'E, JRC 9164; just out of

Pine Creek, on the road to Molina, BVG2322-24; 10 km N of Laura, Qld (JD); DL720, Bensbach River, Wondo village, Western Province, PNG, 8°53'S, 141°17'E; DL880 (S18919), Flying Fox Creek, Kapalga, N.T., 12°40'S, 132°19'E; DL834 (S18910), Cambridge Gulf, W.A., 14°55'S, 128°34'E; DL839 (S18911), Ningbing Range Road, N.T., 15°02'S, 128°36'E; DL854 (S18915), Theda Station, Kalumburu, W.A., 14°48'S, 126°23'E; DL805 (S18903), East Baines River, N.T., 13°09'S, 130°35'E; DL790 (S18915), Wongi, W of Litchfield N.P., N.T., 13°09'S, 130°35'E; DL769 (S18965), Oriomo "Field Station", Oriomo River, Western Province, PNG, 8°51'S, 143°11'E.

### *Melaleuca* sp. "Bukbuluk"

Kakadu N.P., collect by N. Ashwathappa

### *Melaleuca* sp. "Cook District"

2.4 km west of Lydia Creek on the road to Mission River, 12°33'S; 142°34'E, JRC 9153; Lakefield National Park, ca 13 km due N of New Laura, 15°03', 144°20'E, alt 35m, JRC9783 & VJN.

### *Melaleuca* sp. "Laura"

Laura River crossing a few km S of Laura, JD2050-2052.

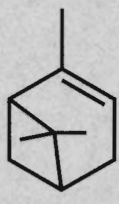
Collections were made by the following people, to whom a great debt of thanks is due:

- N. Ashwathappa
- Joe Brophy [JJB]
- John Clarkson [JRC]
- Lyn Craven [LAC]
- John Doran [JD]
- Paul Forster [PF]
- Robert Goldsack [RJG]
- Brian Gunn [BVG]
- Erich Lassak [EVL]
- David Lea [DL]
- Brendan Lepschi [BJL]
- Maurice McDonald [MM]
- Jock Morse [GJM]
- John Neldner [VJN]

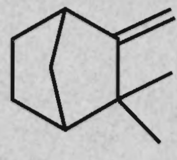
Some samples have "S" numbers. These refer to Australian Tree Seed Centre numbers. ND Rd refers to a National Development road.

# Appendix 2

## Structures of compounds mentioned in this report



α-pinene



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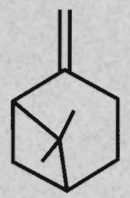
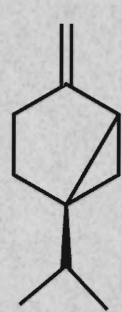


β-pinene



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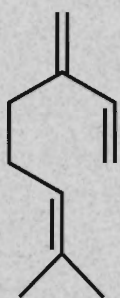
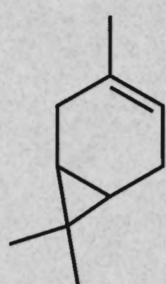


myrcene



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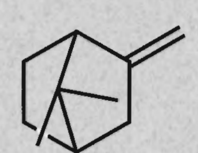
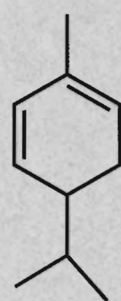
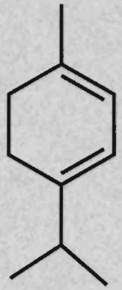


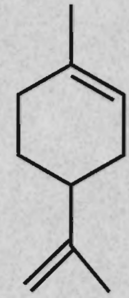
α-fenchene



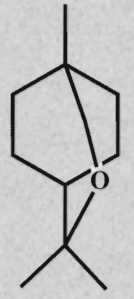
α-phellandrene



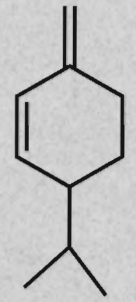
α- terpinene



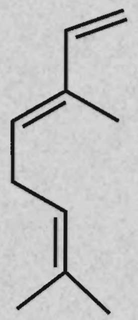
limonene



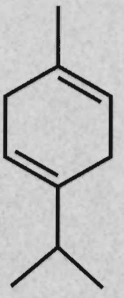
1,8-cineole



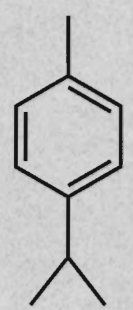
β- phellandrene



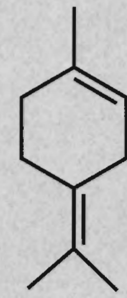
E-β-ocimene



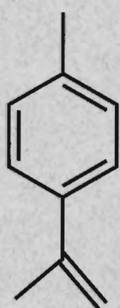
γ- terpinene



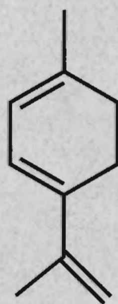
*p*-cymene



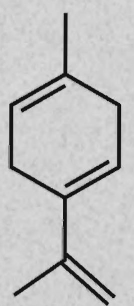
terpinolene



α-p-dimethylstyrene



mentha-1,3,8-triene



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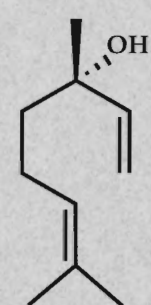
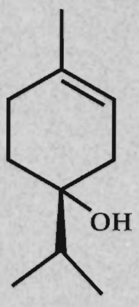
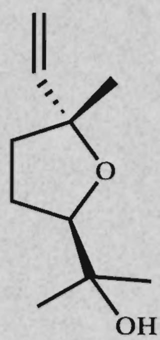


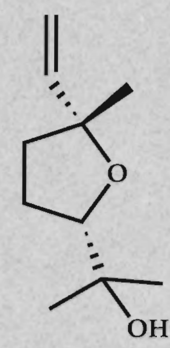

linalool




terpinen-4-ol




*trans*-linalool oxide

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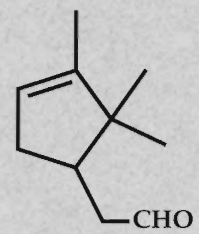
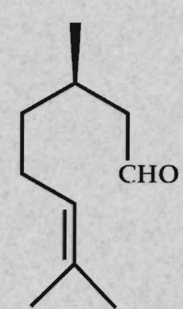
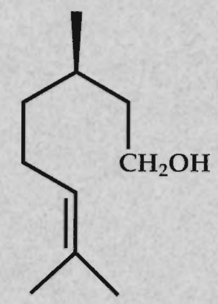


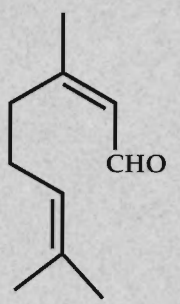

campholenic aldehyde



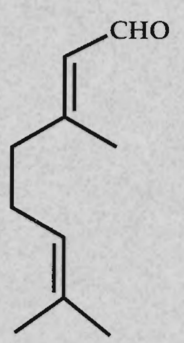

citronellal



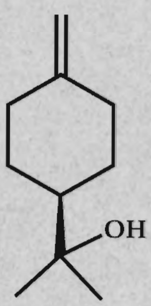

citronellol



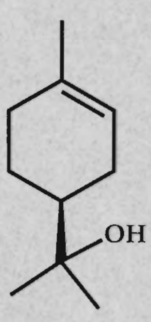

neral



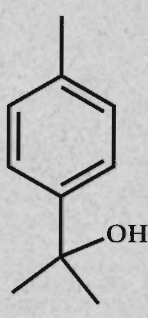

geranial



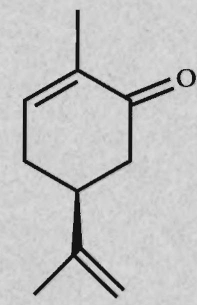

δ-terpineol



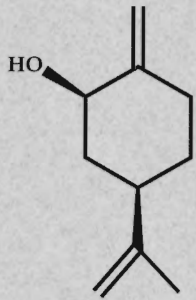

α- terpineol




*p*-cymene-8-ol




carvone

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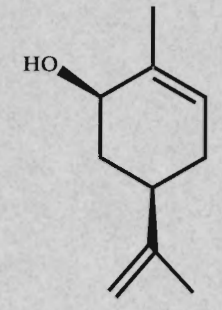


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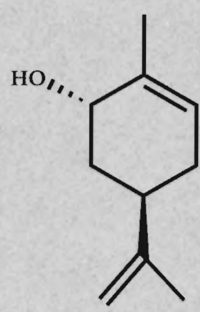


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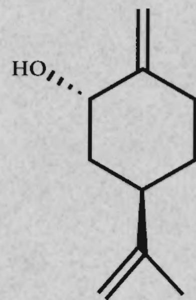


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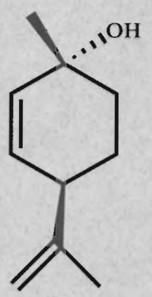


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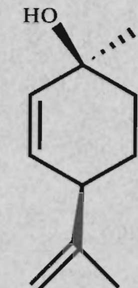


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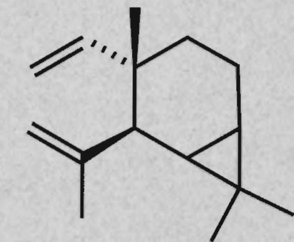
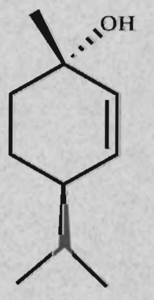


bicycloelemene

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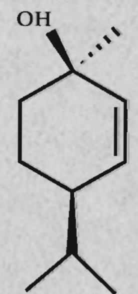


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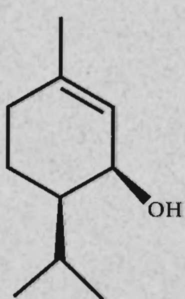
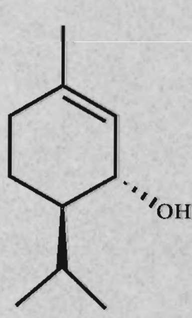



*cis*-piperitol

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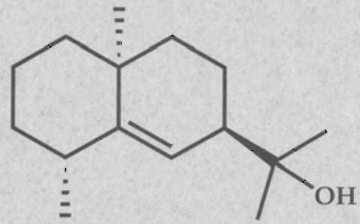
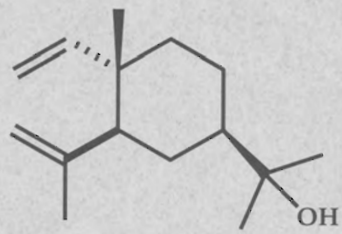
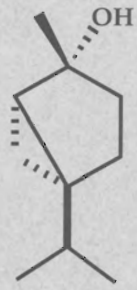



rosifoliol




elemol

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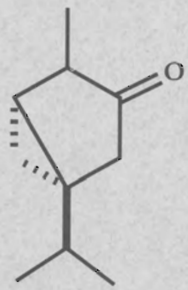


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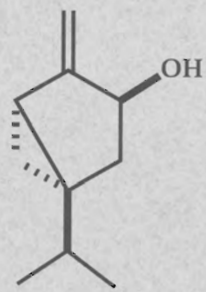
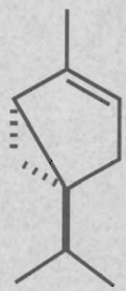
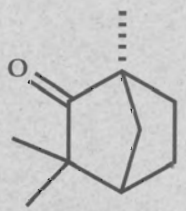



*cis*-sabinol



α-thujene

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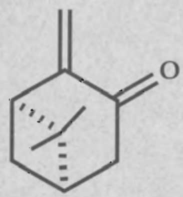


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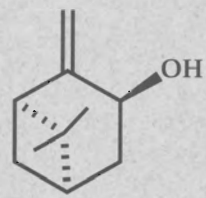


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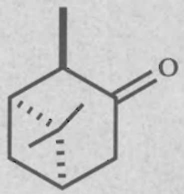

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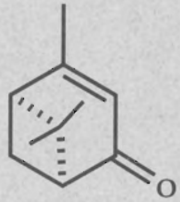

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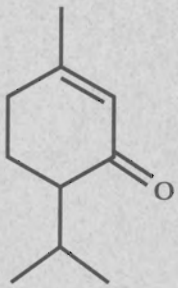

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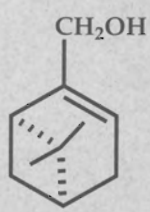

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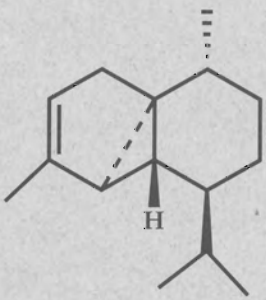

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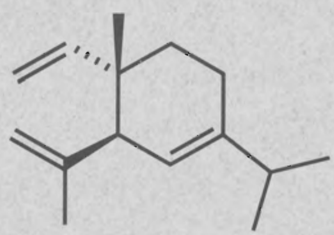

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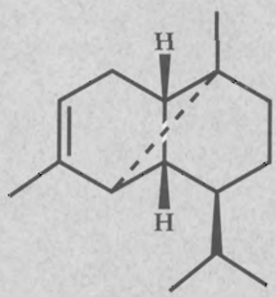
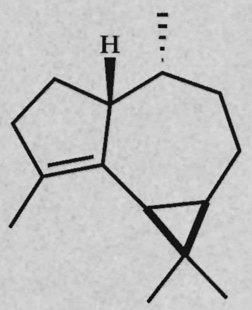


α-copaene



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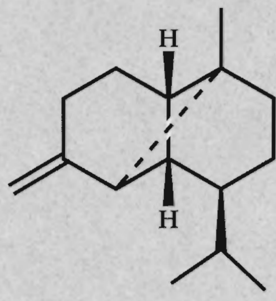

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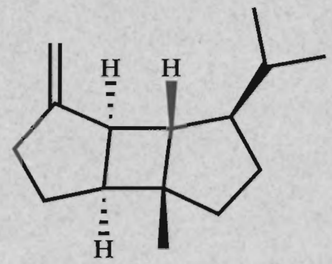

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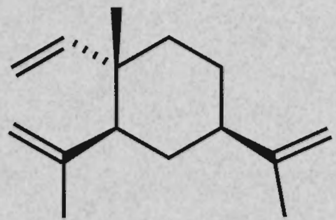

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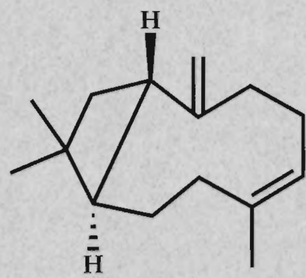

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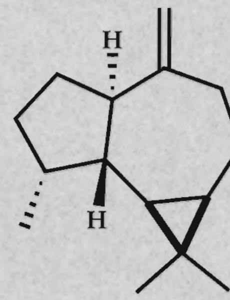

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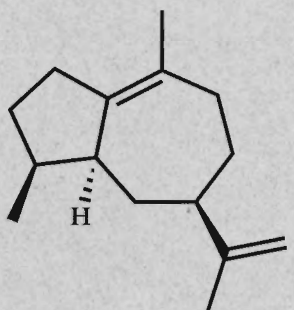

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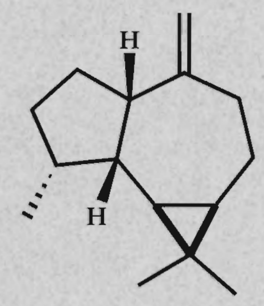

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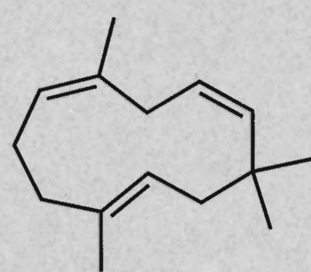

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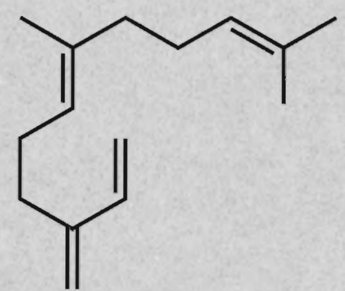

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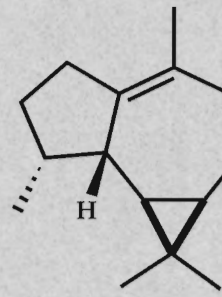


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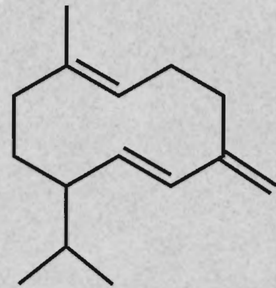

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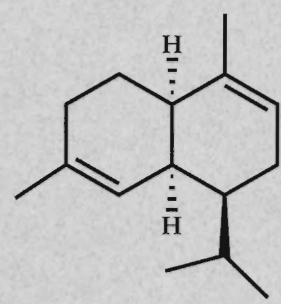


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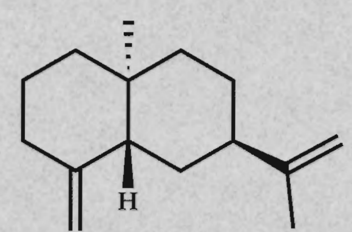


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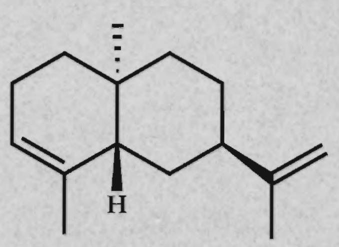


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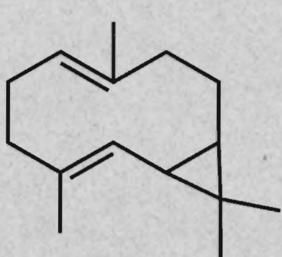

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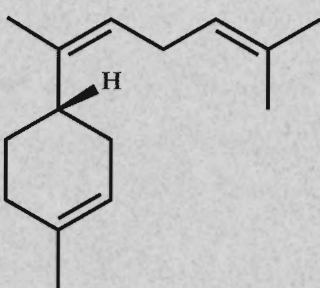
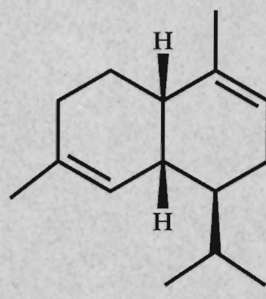
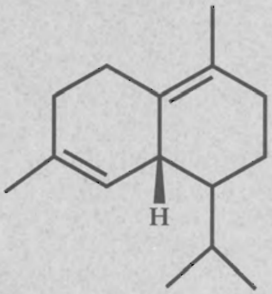


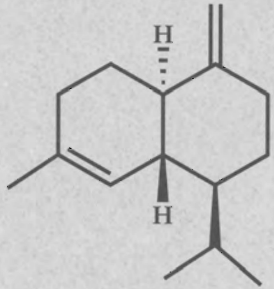

Z-α-bisabolene



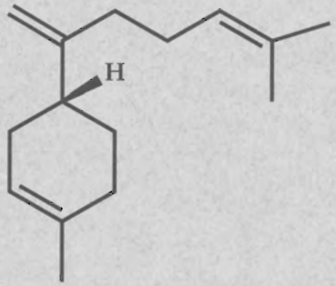

α-muurolene




δ- cadinene




γ-cadinene

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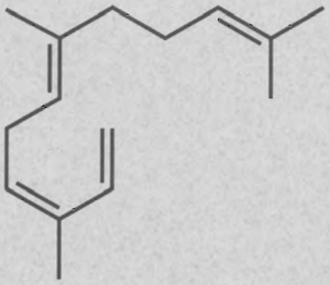
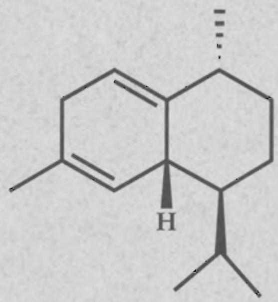


α- farnesene

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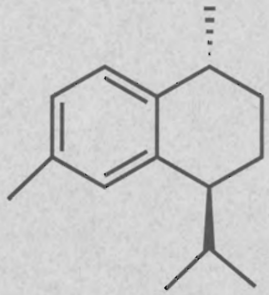

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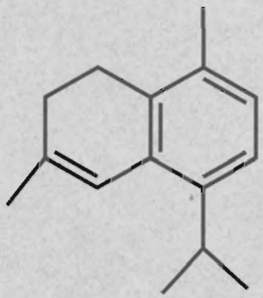

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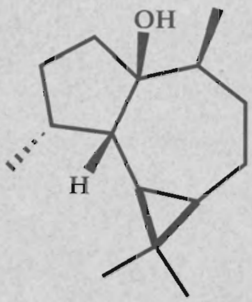


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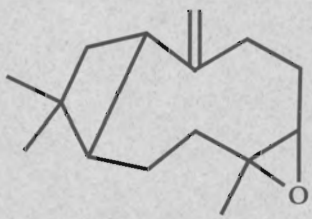
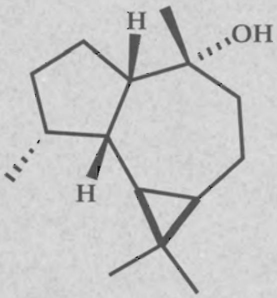



caryophyllene oxide

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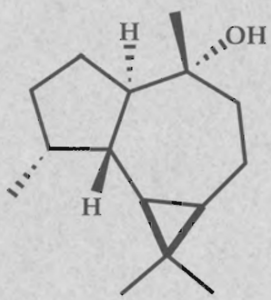


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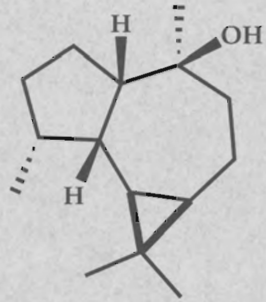


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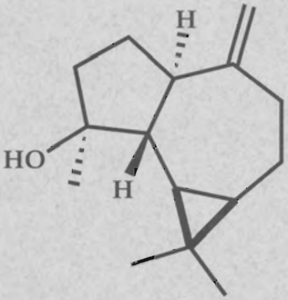


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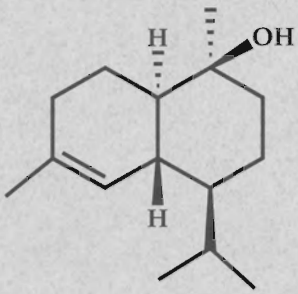
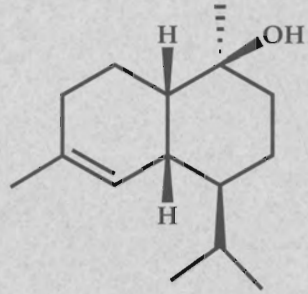
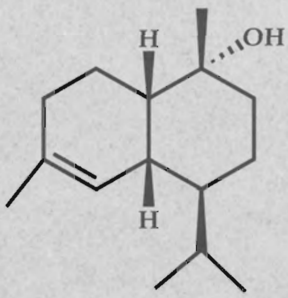


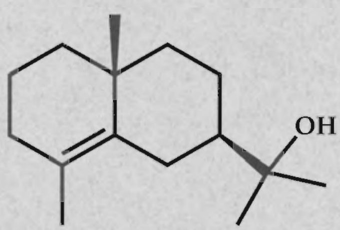

T-cadinol



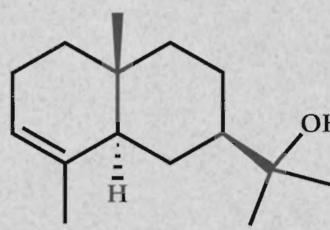

T-muurolol



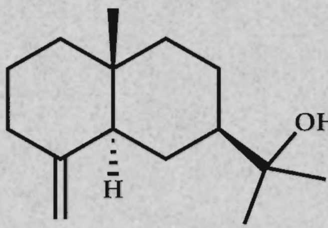

δ-cadinol



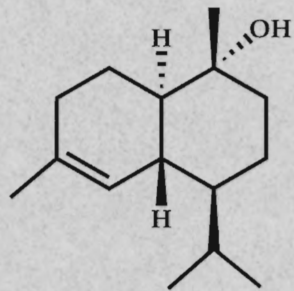

γ- eudesmol



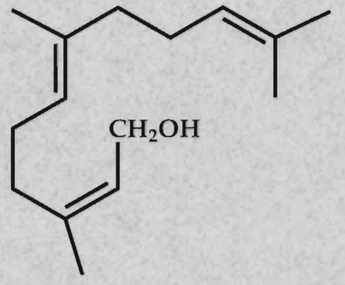

α-eudesmol



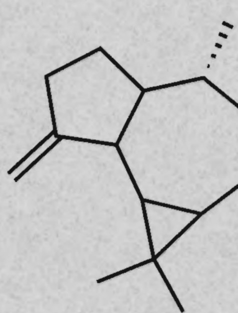
β-eudesmol



α-cadinol



E,E-farnesol



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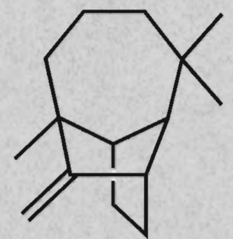
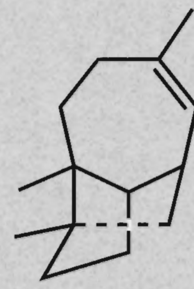


longifolene



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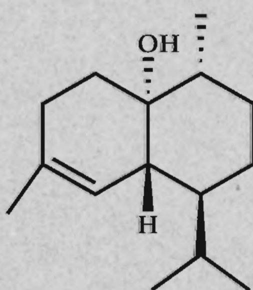

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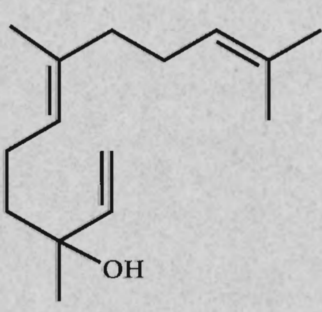
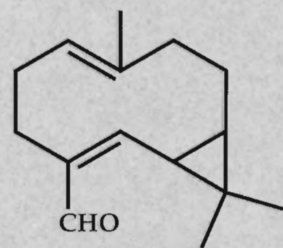
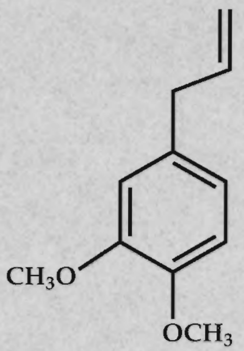


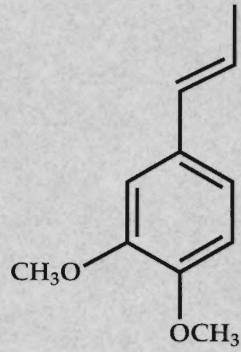
nerolidol



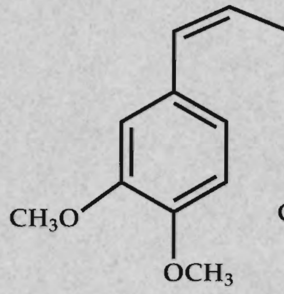
isobicyclogermacral



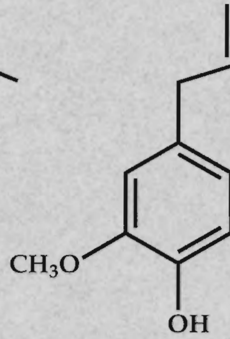

methyleugenol



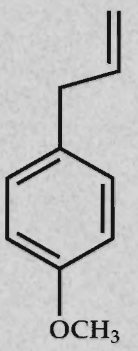

E-methyl isoeugenol



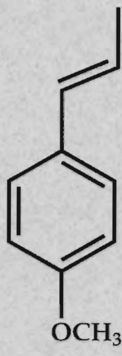

Z-methyl isoeugenol




eugenol




methylchavicol

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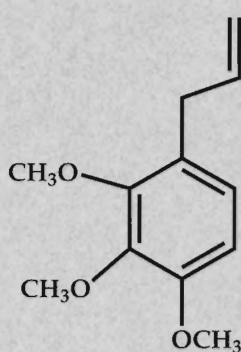
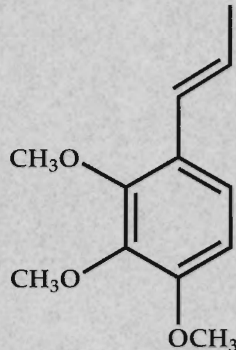
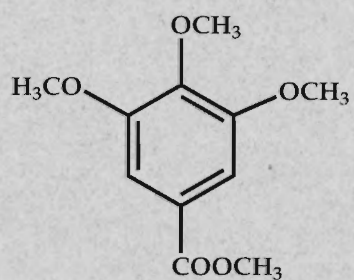


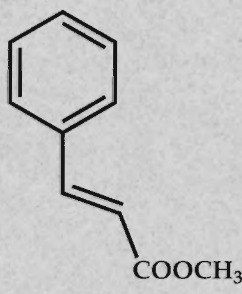

elemicin



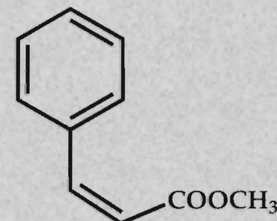

E-isoelemicin



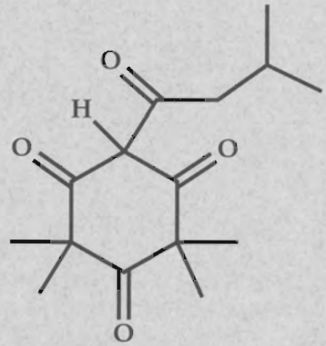

methyl eudesmate




E-methyl cinnamate




Z-methyl cinnamate



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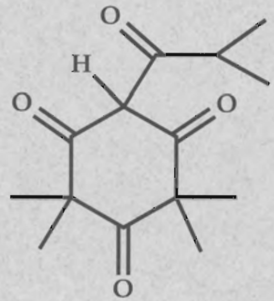
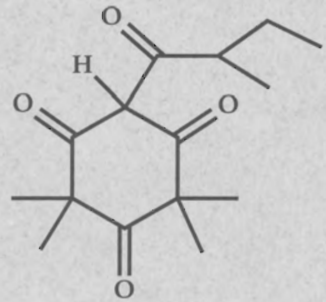
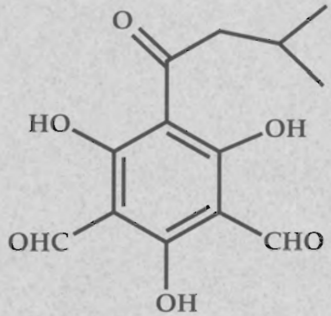


flavesone



isoleptospermone



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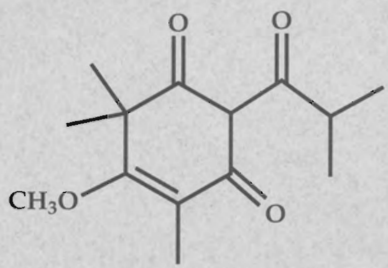

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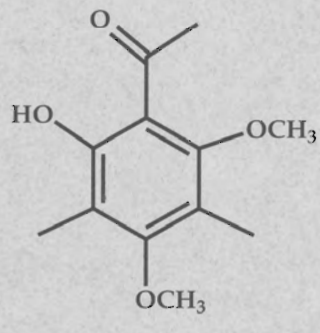

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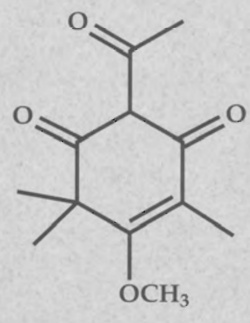

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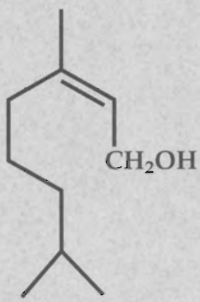


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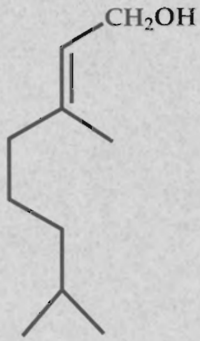


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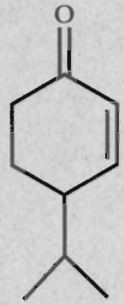


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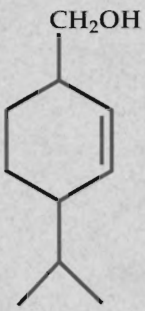


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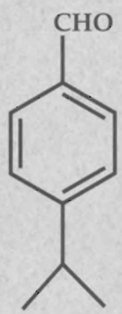


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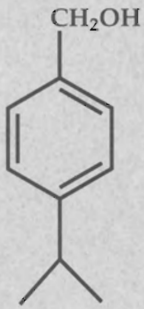


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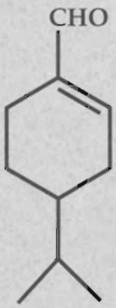


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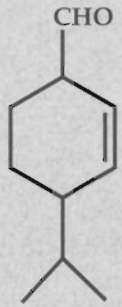


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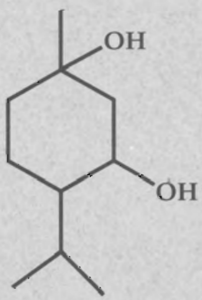


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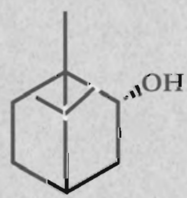


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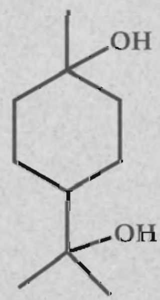


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